APPENDIX 15-Q
MMER FISH HABITAT COMPENSATION PLAN

Seabridge Gold Inc.

KSM PROJECT
MMER Fish Habitat Compensation Plan

SEABRIDGE GOLD

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KSM PROJECT
MMER FISH HABITAT COMPENSATION PLAN

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SEABRIDGE GOLD

Seabridge Gold Inc.

Prepared by:

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Vancouver, British Columbia

Executive Summary

This report presents a fish habitat compensation plan for the proposed KSM Project. This plan has been developed with input from Fisheries and Oceans Canada (DFO), the British Columbia Ministry of Environment, and Aboriginal groups (Section 11 Order) as part of the KSM Project Technical Working Group. The purpose of this compensation plan is to ensure that the Project follows DFO's habitat compensation measures required to offset loss of the productive capacity of fish habitat.

This report discusses fish habitat compensation related to the deposit of deleterious substances within fish-bearing watercourses of the proposed Tailing Management Facility (TMF) and related seepage collection ponds. Compensation for the loss of fish habitat within the TMF is governed by Section 36(1) of the *Fisheries Act* (1985): Metal Mining Effluent Regulations (SOR/2002-222).

The objectives of the compensation plan are to follow regulatory requirements of DFO's Fisheries Authorization, including to:

- describe the physical and biological characteristics of the habitat that will be lost;
- propose technically feasible compensations projects (as per legislated guidelines) that will provide compensatory habitat at a minimum 2:1 ratio;
- describe the methods that were used to prepare a habitat budget;
- describe the methods that will be used to mitigate the effects of habitat construction; and
- describe the post-monitoring evaluation program.

Field assessments implemented in 2008 and 2009 provided the information necessary to describe the physical habitat (bankfull width, bankfull depth, gradient, stream length, etc.) and biological (riparian cover, instream cover, fish community) attributes of each stream and reach where a loss of fish habitat will occur within the TMF. This information was used to assign fish habitat suitability indices to each stream and wetland.

The total area of habitat that will be lost was calculated from the proposed TMF and seepage collection pond design. By multiplying each area by the appropriate habitat suitability indices, habitat units (HUs) that incorporate both quantity and quality of habitat were calculated.

Pre-field planning and field assessments implemented in 2009, 2010, and 2011 provided the information necessary to identify technically feasible compensation projects. Two compensation projects were identified as compensation sites to offset fish habitat loss within the TMF. These two projects are located in the Treaty and Bell-Irving watersheds. Existing site conditions, project objectives and techniques, and designs are discussed for each project within the report. The total number of HUs that will be created are presented for each project.

A Habitat Evaluation Procedure was used to prepare a habitat budget. Peer-reviewed habitat suitability indices were used for HU calculation. A peer-reviewed habitat suitability model does not exist for Dolly Varden, the only species of fish present within the TMF; hence, habitat suitability indices values were obtained from a search of the scientific literature on Dolly Varden habitat preferences.

A total area of 89,620 m^2 (8.96 ha) of fish habitat will be lost from South Teigen and North Treaty watersheds due to the deposit of deleterious substances into the proposed TMF and seepage collection ponds. This represents a total of 153,982 HUs.

A total area of 200,176 m^2 (20.0 ha) of fish habitat will be created as a result of the two proposed technically feasible compensation projects. This area represents a total of 363,389 HUs.

The ratio of compensatory habitat area, in this plan, to lost habitat area is 2.2:1. The ratio of compensatory HUs to lost HUs is 2.4:1, which is greater than the minimum 2:1 ratio typically requested by DFO. Therefore, the requirements to compensate for project related fish habitat loss has been effectively achieved. However, when fish habitat compensation construction proceeds, projects will be built according to a 2:1 ratio of compensatory HUs to lost HUs.

Acknowledgements

This report was prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd. The project was managed and this report written by Christopher Burns (B.Sc., R.P.Bio.). Other contributors to the report were Steve Jennings (B.Sc., R.P.Bio.) and Kyla Warren (M.Sc.). Bob Askin (P.Eng.), Doug Griffin (RPF), and David Luzi (M.Sc.) provided technical field experience related to fish habitat compensation planning and design. François Landry (M.Sc., R.P.Bio.) provided senior technical review and support. Report production was coordinated by Robert Tarbuck (Publishing), Francine Alford (Graphics), Ann Danilevich (Editing), and Pieter van Leuzen (GIS).

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MMER FISH HABITAT COMPENSATION PLAN

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Acronyms and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BACI	Before After Control Impact
BC	British Columbia
BC MOE	British Columbia Ministry of Environment
BC MOF	British Columbia Ministry of Forests
BC MWLAP	British Columbia Ministry of Water, Land and Air Protection
BMP	best management practices
DFO	Fisheries and Oceans Canada
FHAP	fish habitat assessment procedures
FINS	FINS Consulting Ltd.
HADD	harmful alteration, disruption, or destruction
HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability Index
HU	Habitat Unit
LWD	large woody debris
MAF	mean annual flow
MMER	Metal Mining Effluent Regulations (SOR/2002-222)
Plan, the	the MMER Fish Habitat Compensation Plan
Project, the	the KSM Project
RISC	Resources Information Standards Committee
REE	routine effectiveness evaluation
Rescan	Rescan Environmental Services Ltd.
SE	standard error
Seabridge	Seabridge Gold Inc.
SHIM	Sensitive Habitat Inventory Mapping
SI	suitability index
TMF	Tailing Management Facility
UTM	Universal Transverse Mercator

1. Introduction

1.1 PROJECT PROPONENT

Seabridge Gold Inc. (Seabridge) is the proponent for the proposed KSM Project (the Project), a gold, copper, silver, molybdenum mine.

1.2 PROJECT LOCATION

The Project is located in the coastal mountains of northwestern British Columbia. It is approximately 950 km northwest of Vancouver and 65 km northwest of Stewart, within 30 km of the British Columbia–Alaska border (Figure 1.2-1).

1.3 PROJECT OVERVIEW

The Project is located in two geographical areas: the Mine Site and Processing and Tailing Management Area (PTMA), connected by twin 23-km tunnels, the Mitchell-Treaty Twinned Tunnels (Figure 1.3-1). The Mine Site is located south of the closed Eskay Creek Mine, within the Mitchell, McTagg, and Sulphurets Creek valleys. Sulphurets Creek is a main tributary of the Unuk River, which flows to the Pacific Ocean. The PTMA is located in the upper tributaries of Teigen and Treaty creeks. Both creeks are tributaries of the Bell-Irving River, which flows to the Nass River and into the Pacific Ocean. The PTMA is located about 19 km southwest of Bell II on Highway 37.

The Unuk and Bell-Irving rivers are large river systems with high fisheries and cultural values. They provide important spawning routes for Pacific salmon (all species) and anadromous steelhead trout, as well as habitat for resident trout (cutthroat and rainbow), resident char (Dolly Varden and bull trout), and mountain whitefish.

The Mine Site will be accessed by a new road, the Coulter Creek Access Road, which will be built from km 70 on the Eskay Creek Mine Road. This road will follow Coulter and Sulphurets creeks to the Mine Site. The PTMA will also be accessed by a new road, the Treaty Creek Access Road, the first 3-km segment of which is a forest service road off of Highway 37. The Treaty Creek Access Road will parallel Treaty Creek.

Four deposits will be mined at the KSM Project—Kerr, Sulphurets, Mitchell, and Iron Cap—using a combination of open pit and underground mining methods. Waste rock will be stored in engineered rock storage facilities located in the Mitchell and McTagg valleys at the Mine Site. Ore will be crushed and transported through one of the Mitchell-Treaty Twinned Tunnels to the PTMA. This tunnel will also be used to route the electrical power transmission lines. The second tunnel will be used to transport personnel and bulk materials. The Process Plant will process an average of 130,000 tpd of ore to produce a daily average of 1,200 t of concentrate. Tailing will be pumped to the Tailing Management Facility from the Process Plant. Copper concentrate will be trucked from the PTMA along highways 37 and 37A to the Port of Stewart, which is approximately 170 km away via road.

The mine operating life is estimated at 51.5 years. Approximately 1,800 people will be employed annually during the Operation Phase. Project Construction will take about five years, and the capital cost of the Project is approximately US$5.3 billion.

Figure 1.2-1

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KSM PROJECT

KSM Project Location

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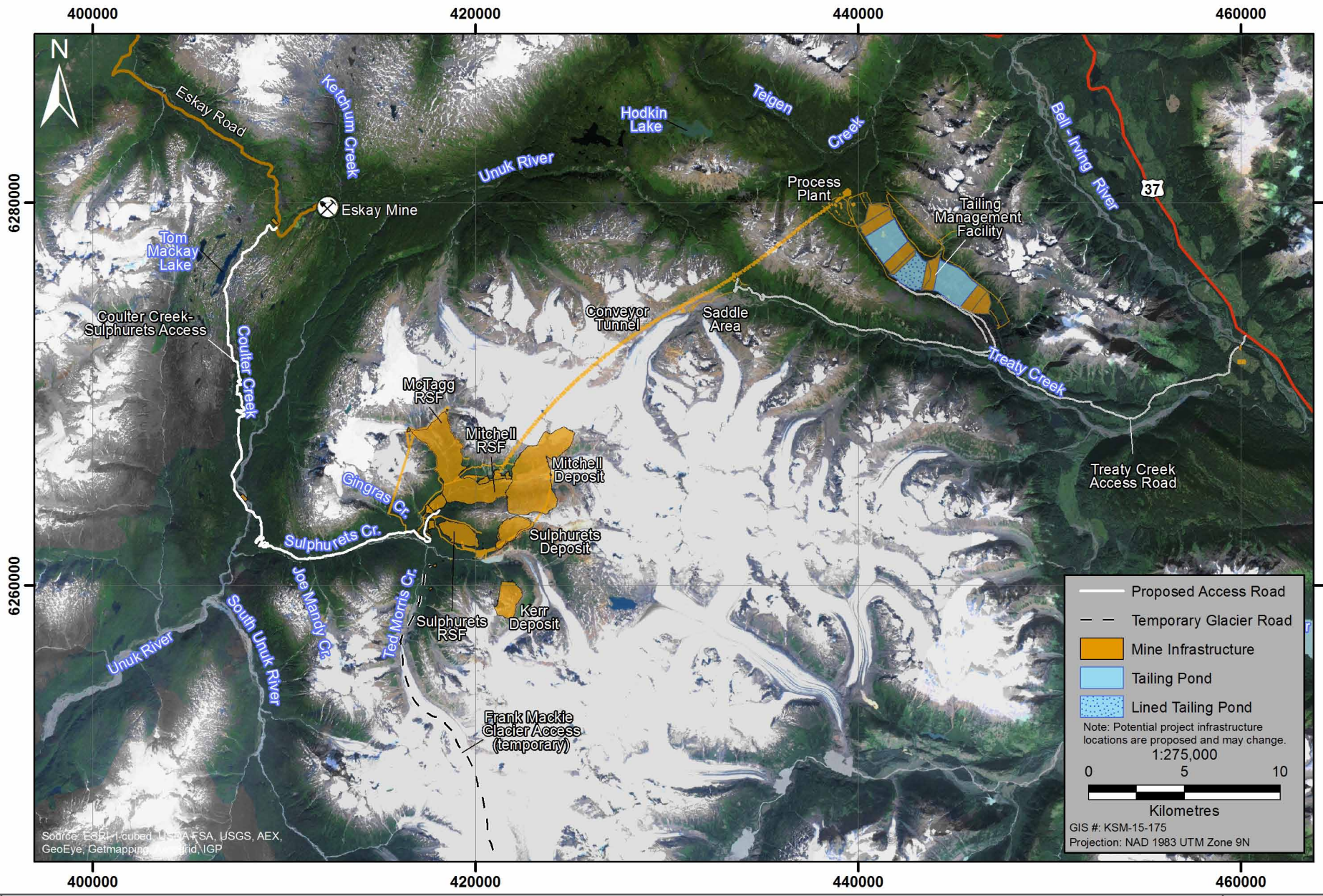

Figure 1.3-1

SEABRIDGE GOLD
KSM PROJECT

KSM Project Layout

Figure 1.3-1

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Fish habitat will be impacted by the Project in two ways: 1) deposition of tailings into a fish-bearing watercourse, which requires an authorization under Section 36 of the *Fisheries Act* (1985), and 2) loss of fish habitat due to Project infrastructure (e.g., roads, transmission line, dams), which requires an authorization under Section 35 of the *Fisheries Act*. This report is concerned exclusively with compensation related to the deposit of deleterious substances within fish-bearing watercourses of the Tailing Management Facility (TMF) and seepage collection ponds. Compensation for the loss of fish habitat within the TMF is governed by Section 36(1) of the *Fisheries Act:* Metal Mining Effluent Regulations (MMER; SOR/2002-222). A companion document entitled *KSM Project: HADD Fish Habitat Compensation Plan* (Rescan 2012c) provides a compensation plan for Section 35 of the *Fisheries Act*.

This report presents a fish habitat compensation plan (the Plan) related to the deposit of deleterious substances within fish-bearing watercourses of the TMF and seepage collection ponds for the proposed Project. This Plan has been developed with input from Fisheries and Oceans Canada (DFO), the British Columbia Ministry of Environment (BC MOE), and Aboriginal groups based upon continual Project Technical Working Group meetings and consultation. This Plan has been developed according to guidelines developed for the Project by DFO's Environmental Assessment Analyst on July 27, 2010 (Appendix 1.1-1). The purpose of the guidelines is to ensure that the Project follows DFO's *No Net Loss* principle for the management of fish habitat (DFO 1986).

1.4 REGULATORY FRAMEWORK

1.4.1 Legislation

In June 2012, the federal government proposed amendments to the *Fisheries Act* (1985). The proposed changes would result in a shift for DFO from a focus on managing impacts to all fish habitat to managing threats to fisheries. These amendments would support the long-term productivity and sustainability of Canada's commercial, recreational, and Aboriginal fisheries. The current *Fisheries Act* provisions used for the review of Project affects are indiscriminate and require consideration of all projects, on all waters, regardless of the importance of fish species present or their contribution to fisheries.

Currently, DFO is in a transition phase with respect to implementing *Fisheries Act* (1985) legislative changes. During the transition phase, the existing provision of the *Fisheries Act* will continue to apply. The transition phase is expected to last until January 2013, at which time the legislative changes are expected to come into force. Following the legislative changes, DFO's *Policy for Management of Fish Habitat* (1986) and guiding principle of *No Net Loss* will be changed. However, the details on the timing of policy changes are unknown at the time of production of this Plan. Therefore, the current *Fisheries Act* (1985) legislation and policies are discussed below, because they set the stage on how the Plan was developed.

Fish and fish habitat are protected under a variety of federal and provincial regulatory acts and principles. The *Fisheries Act* (1985) prohibits the harmful alteration, disruption, or destruction (HADD) of fish habitat through physical, chemical or biological means. *The Policy for the Management of Fish Habitat* (DFO 1986) puts forth the principle of "no net loss of productive capacity" of fish habitat (*No Net Loss*).

Under Section 35(2) of the *Fisheries Act* (1985), any project or activity that causes a HADD requires an authorization from DFO. The *Fisheries Act* defines fish habitat as "spawning grounds, nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." Included in this definition are both fish-bearing and non-fish bearing waterbodies, including the surrounding riparian area and fisheries sensitive zones.

The MMER (SOR/2002-222), enacted in 2002, were developed under Section 36 of the *Fisheries Act* (1985) to regulate the deposit of tailing and other waste matter produced during mining operations into

natural fish-bearing waters. These regulations, administered by Environment Canada, are for both new and existing mines. If a developer proposes to use a natural fish-bearing waterbody for tailing management, then a fish habitat compensation plan must be developed to ensure no net loss of fish habitat results from the use of this waterbody.

The fish habitat definition is articulated by DFO in a decision framework that evaluates the type and magnitude of potential changes to aquatic habitat by posing five questions. By answering these questions, DFO gathers information necessary to support a decision on whether a HADD is created and if so, whether the HADD can be authorized. The HADD decision framework (DFO 1998) asks these questions:

1. *Is fish habitat present at the project site or in an area potentially impacted by the project?*
2. *Could the proposed project cause a HADD of fish habitat?*
3. *Can the impacts to fish habitat be fully mitigated?*
4. *Should the HADD be authorized?*
5. *Can the HADD be compensated?*

1.4.2 The *No Net Loss* Principle

The objective of the DFO *No Net Loss* principle is to balance unavoidable habitat losses with habitat replacement. This principle prevents further reductions to fish populations and fish habitat. *No Net Loss* is achieved through a hierarchy of preferences (DFO 1998):

- avoidance of a HADD through the redesign of the project;
- compensation by replacing lost habitat with similar habitat in the same ecological unit (i.e., like-for-like compensation);
- compensation by increasing the productive capacity of existing habitat with unlike habitat in the same ecological unit;
- compensation by replacing lost habitat with natural habitat in another ecological unit; and
- compensation by using artificial production (i.e., building hatcheries or fertilizing lakes).

In developing the Plan, a key guiding principle is to ensure the amount of compensation is equal to at least a 2:1 gain to loss ratio to ensure certainty of success to maintain the overall net productive capacity.

1.5 OBJECTIVES AND APPROACH

The primary objective of Seabridge Gold Inc. (Seabridge) is to work in a collaborative, open manner to compensate for Project-related fish habitat lost by enhancing existing habitat or creating habitat using a variety of techniques and projects to benefit fish and aquatic habitat.

In developing the Plan for the Project, the general approach follows DFO's (1986) *Policy for Management of Fish Habitat* guiding principle of *No Net Loss*. Through the hierarchy described above and procedures outlined in the policy, the *No Net Loss* principle is designed to be flexible in finding a solution to managing fish habitat.

The Plan has been developed so that regulatory agencies and Aboriginal groups can review the approach and proposed technically feasible compensation projects. To be transparent, each procedural approach in the development of the Plan and compensation projects have been further subdivided and presented below:

- **Fish and aquatic habitat data compilation** – Relevant fish and fish habitat information within and outside of the fisheries study area was obtained from a variety of sources. These sources include, but are not limited to, environmental assessments, provincial and federal databases and reports, Aboriginal group databases and reports, and consultant and industry reports.
- **Determination of predicted Project effects** – Using the data collated in baseline reports (Rescan 2009, 2010, 2011, 2012a, 2012b) and the Project description, the predicted Project effects to fish and fish habitat were assessed (Rescan 2012b).
- **Habitat evaluation and habitat loss calculation** – Review and calculation of fish habitat loss (i.e., HADDs). Calculation of habitat loss was based upon the Habitat Evaluation Procedure (HEP) developed by US Fish and Wildlife Service (1980).
- **Watershed analysis** – Review and determination of limiting habitat factors affecting the productive capacity of fish habitat within and outside of study area watersheds.
- **Regional objectives identification** – A review of federal (e.g., DFO) and provincial (e.g., BC MOE) fisheries management objectives for fish and fish habitat was completed. This information was used to select and evaluate potential compensation projects.
- **Aboriginal groups** – Traditional knowledge and traditional use, available through Fisheries Technical Working Group meetings, consultation, and reports were used in baseline data gathering and were incorporated into the process of project identification. Further traditional knowledge will be incorporated as the Plan develops.
- **Option compilation** – Conceptual habitat compensation options were identified through a desktop analysis and fieldwork.
- **Species at risk and rare ecosystems identification** – Compensation projects were reviewed as they pertain to compliance with federally listed species, under the *Species at Risk Act* (2002), and provincially rare species/ecosystems.
- **Option analysis** – Each compensation option was assessed against a series of environmental and habitat screening criteria. Based on this analysis, the most suitable projects were selected for further analysis. Technical feasibility designs were completed for the most suitable projects.

Details of the above procedural approach are discussed in following sections.

2. Project Overview and Fisheries Resources

2.1 PROJECT OVERVIEW

The Plan relates specifically to fish habitat impacts resulting from the deposit of deleterious substances into the TMF, which includes the seepage collection ponds. The proposed TMF is situated within two watersheds, South Teigen and North Treaty creeks (Figure 2.1-1). South Teigen and North Treaty creeks possess a watershed area of 61 and 33 km^2, respectively. Within South Teigen and North Treaty watersheds, the proposed TMF encompasses 12.6% (7.7 km^2) and 14.5% (4.8 km^2), respectively.

South Teigen Creek originates from a glacier on the eastern hillslope and flows into a broad, flat valley surrounded by wetland fen habitat (Plates 2.1-1 and 2.1-2). The creek gradient then increases, flowing through a confined valley with a 2.5 m falls (Plates 2.1-3 and 2.1-4). Downstream of the falls, the creek flows through an unconfined valley and discharges into Teigen Creek (Plate 2.1-5).

North Treaty Creek originates from two sources, an eastern hillslope and wetland complexes on the valley floor. The eastern hillslope provides a significant water source during the freshet and early summer, after which the flow is reduced (Plate 2.1-6). The wetland complex provides continuous water sources throughout the year (Plate 2.1-7). Both water sources merge to form North Treaty Creek. The creek flows in a low gradient valley surrounded by riparian shrub habitat (Plate 2.1-8). The creek gradient then increases, flowing through a confined valley (Plate 2.1-9) and discharging into a larger tributary. The larger tributary, called Tumbling Creek for the purposes of this report, originates from the eastern hillslope and eventually discharges into Treaty Creek (Plate 2.1-10).

A Process Plant will be located within South Teigen watershed. The tailing will be pumped from the plant to the TMF located in the upper reaches of the South Teigen and North Treaty creeks. Two dams will be constructed, one on each end of the TMF (North Dam and South Dam; Figure 2.1-1), with storage capacity for the life of the Project within an area 8 km long and 1.5 km wide. Two dams will be constructed within the TMF, the Splitter Dam and Saddle Dam. These dams will form a lined pond within the TMF. A temporary Saddle Seepage Collection Dam will be constructed during the operation of the North TMF Cell. When the South TMF Cell is constructed, the Saddle Seepage Collection Dam will be flooded with tailings. Any seepage from the dams will be collected in ponds below the dams and pumped back into the impoundment to reduce any potential impact on downstream drainages. Water diversion channels will be constructed on both flanks of the impoundment, where feasible, to divert clean water away from the impoundment. Supernatant water will be recovered from the impoundment using barge-mounted pumps and recycled to the plant for process water.

2.2 FISH AND FISH HABITAT RESOURCES

Dolly Varden (*Salvelinus malma*) is the only fish species present in South Teigen Creek, above the falls, and in North Treaty Creek.

Field assessments of fish and fish habitat within South Teigen and North Treaty watersheds were conducted in 2008, 2009, 2010, and 2011. Baseline reports present detailed results of these assessments; therefore a summary of fish habitat is presented in the Plan (Rescan 2009, 2010, 2011, 2012b). For the purposes of describing fish habitat within these watersheds, streams were grouped according watershed location and habitat type: South Teigen Creek, South Teigen tributaries, North Treaty Creek, and North Treaty tributaries.

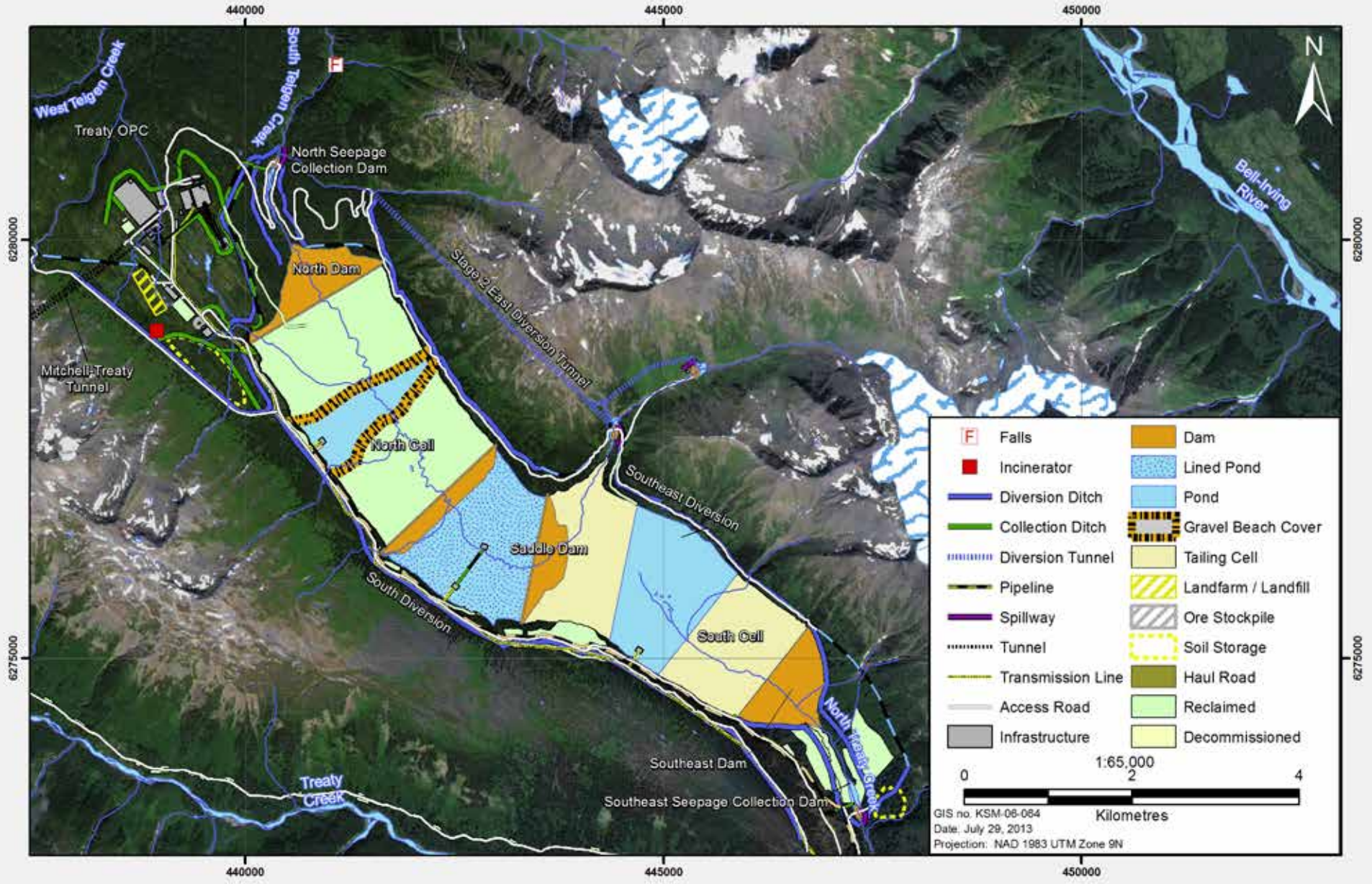

Figure 2.1-1

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KSM PROJECT

Proposed TMF within South Teigen and North Treaty Creeks

Figure 2.1-1

Rescan
Engineers & Scientists

Plate 2.1-1. South Teigen Creek along eastern hillslope.

Plate 2.1-2. South Teigen Creek within flat valley.

Plate 2.1-3. South Teigen Creek within confined valley.

Plate 2.1-4. South Teigen Creek falls.

Plate 2.1-5. South Teigen Creek downstream of falls.

Plate 2.1-6. North Treaty Creek along eastern hillslope in August.

Plate 2.1-7. North Treaty Creek wetland complex.

Plate 2.1-8. North Treaty Creek within low gradient valley.

Plate 2.1-9. North Treaty Creek within confined valley.

Plate 2.1-10. Tumbling Creek downstream of North Treaty Creek confluence.

Channel characteristics vary between mainstem reaches and tributaries. Generally, South Teigen Creek has a larger average bankfull width (7.7 m vs. 5.7 m) and depth than North Treaty Creek. North Treaty Creek has a higher average channel gradient than South Teigen Creek. South Teigen tributaries have a larger average bankfull width (1.9 m) and depth (0.3 m) than North Treaty tributaries (1.2 and 0.3 m). South Teigen tributaries have a greater occurrence of residual pools compared to North Treaty tributaries.

South Teigen tributaries have a higher average channel gradient than North Treaty tributaries. Channel morphology varies between mainstem reaches and tributaries (Figure 2.2-1 [map pocket]). There is a higher proportion of riffle-pool morphology in North Treaty Creek (83.7%) compared to South Teigen Creek (46.9%), which is dominated by cascade-pool morphology. There is a higher proportion of riffle pool morphology in North Treaty tributaries (82.4%) compared to South Teigen tributaries (46.0%), which have high proportions of cascade-pool (24.3%) and step-pool (27.1%) morphology.

The habitat unit (HU) ratio is evenly distributed between three habitat types (riffle, pool, cascade) for North Treaty Creek. In comparison, HU ratio favours riffle and cascade habitat types in South Teigen Creek. There is a higher proportion of riffles in North Treaty tributaries (79.0%) compared to South Teigen tributaries (50.2%), which have a high proportion of cascades.

Substrate is a key component of fish habitat due to its physical properties and its biological functions (e.g., invertebrate habitat, cover for fish, and incubator of fish embryos). The habitat weighted substrate composition is evenly distributed between three substrate types (fines, gravel, cobble) for South Teigen Creek. In comparison, habitat weighted substrate composition favours gravel substrates in North Treaty Creek (62.0%). South Teigen tributaries are dominated by gravel substrates and North Treaty tributaries are dominated by fine substrates.

The habitat weighted cover composition is dominated by overhanging vegetation and pool habitat in both South Teigen and North Treaty creeks. However, the proportions of these habitat types are greater in North Treaty Creek. South Teigen and North Treaty tributaries are dominated by overhanging vegetation, 41.4% and 53.9%, respectively.

In general, the more pools within a reach, the better the rearing and overwintering habitat quality (Johnston and Slaney 1996). A very low pool cover proportion in South Teigen Creek indicates less complex habitat, and reduced rearing and overwintering habitat capability (depending upon winter flows). A low occurrence of pools can be explained by several factors. First, the bed substrate has a high composition of cobble, which is resistant to scour and movement at all but peak flows; hence, the bed is very stable. Second, the riparian zone lacks trees that strengthen banks and enable large undercuts to develop. In addition, the channel lacks any large woody debris (LWD) because riparian zones are dominated by shrubs. LWD causes horizontal stream energy and laminar flow to be interrupted and deflected into the banks and bed causing pools to be scoured while also providing cover for fish.

Functional LWD abundance, type, and distribution influence fish habitat quality for all life stages. LWD cover is more abundant in tributaries than mainstem reaches. LWD cover is absent from South Teigen Creek and is more prevalent in North Treaty Creek (9.5%).

Since Dolly Varden are the only fish species located within the TMF, habitat quality assessment are focused on the habitat requirements of juvenile and adult Dolly Varden. Good quality habitat has most or all of the key physical and biological attributes for the life stage and species of interest. Fair quality habitat has some physical/biological features for the life stage but is missing one or two key attributes.

Poor quality habitat has very few physical/biological features for the life history stage and is missing most of the key attributes. No habitat has any of the physical/biological features for the life history stage.

Fair or better rearing habitat quality was observed at 96.6% or better of South Teigen and North Treaty creeks (Figure 2.2-2 [map pocket]). Generally, North Treaty Creek possesses higher quality rearing habitat because of greater habitat diversity and fish habitat cover compared to South Teigen Creek. Furthermore, the overall rearing habitat for juveniles is of higher quality in North Treaty Creek compared to South Teigen Creek based upon electrofishing sampling data. The fish population density results supported the assessment of fair or better rearing throughout these creeks. Summer rearing habitat is not likely a population bottleneck or limiting factor in these creeks because it is abundant, widely dispersed, and supported moderate to high fish densities through the mainstems.

Fair or better rearing habitat quality is similar between South Teigen and North Treaty tributaries, 64.5 and 63.8%, respectively (Figure 2.2-2 [map pocket]). Generally, North Treaty tributaries possess higher quality rearing habitat because of their lower gradient and abundant fish habitat cover compared to South Teigen tributaries. Furthermore, the overall rearing habitat for juveniles is of higher quality in North Treaty tributaries compared to South Teigen tributaries based upon electrofishing sampling data and fish population density results. Typically, as channel gradient increases the quality of rearing habitat decreases. In South Teigen tributaries along the western hillslopes, upstream reaches flowed subsurface during the summer months which isolated the upper reaches from the mainstem. Overall, summer rearing habitat is not likely a population bottleneck or limiting factor in these tributaries because it is abundant, widely dispersed and supports moderate to high fish densities.

In contrast to rearing habitat, which is observed throughout the mainstems and tributaries, South Teigen Creek provides none to poor suitable spawning habitat (Figure 2.2-3 [map pocket]). The high composition of glacial fine substrate and high flows during the spawning season do not provide suitable spawning habitat for Dolly Varden. Furthermore, the lack of adults observed spawning in the mainstem and absence to low abundance of fry in the mainstem support this assessment. The entire length of North Treaty Creek provides good and abundant Dolly Varden spawning habitat due to habitat characteristics, suitable flow, and good water quality.

Fair or better spawning habitat quality was observed at 49.7% of South Teigen tributaries (Figure 2.2-3 [map pocket]). Typically, as channel gradient increases the quality of spawning habitat decreases. South Teigen tributaries possess higher quality spawning habitat in the lower gradient tributary reaches near the mainstem because suitable spawning habitat is present, and the abundance of fry rearing in these reaches based upon electrofishing sampling data. Spawning habitat is not likely a population bottleneck or limiting factor in the South Teigen tributaries. However, the maintenance of winter baseflows to provide sufficient egg incubation along the western and eastern hillslope tributaries is not known since certain tributaries flow subsurface during the summer months.

Fair or better spawning habitat quality was observed at 34.0% of North Treaty tributaries (Figure 2.2-3 [map pocket]). North Treaty tributaries possess higher quality spawning habitat near the wetland complex because of suitable flow, cover, substrate, depth, observation of adults spawning in these tributaries, and the abundance of fry rearing in these streams based upon electrofishing sampling data. The wetland complex likely provides maintenance of baseflows to provide sufficient egg incubation during the winter months. Spawning habitat is not likely a population bottleneck or limiting factor in the North Treaty tributaries.

All reaches of South Teigen and North Treaty creeks provide good overwintering habitat for Dolly Varden (Figure 2.2-4 [map pocket]). This assessment was based upon the presence, frequency and

distribution of pools, adequate residual pool depths, instream cover, and maintenance of base flows throughout the winter months.

Fair or better overwintering habitat quality was observed at 54.3% for South Teigen tributaries (Figure 2.2-4 [map pocket]). The majority of tributaries have very few deep pools and deeper runs of less than 20 cm residual depth, with the exception of Streams 1010, 1016, and 1019 (Figure 2.2-4). As noted previously, the channel morphology is shallow with mean water depths during the high-flow summer period less than 20 cm and even lower winter base flows are predicted. The channels are mostly cobble riffles and runs which are anticipated to provide very little space for overwintering fish.

Fair or better overwintering habitat quality was observed at 25.7% for North Treaty tributaries (Figure 2.2-4 [map pocket]). A high percentage of these tributaries possess no overwintering habitat. The majority of tributaries have no residual pools. As noted previously, the channel morphology is shallow with mean water depths during the high-flow summer period less than 15 cm and even lower winter base flows are predicted. The channels are mostly fines and gravel riffles and runs which are anticipated to provide very little space for overwintering fish. However, tributaries located downstream of the wetland complex may provide sufficient overwintering habitat despite the lack of pools.

Overall habitat quality is based upon all the life history stage rankings (i.e., spawning, rearing, overwintering) previously discussed for each stream segment. All reaches of South Teigen and North Treaty creeks provide important fish habitat for Dolly Varden (Figure 2.2-5 [map pocket]). Important (i.e., good) habitat quality was observed at 68.2% for South Teigen tributaries and 59.4% for North Treaty tributaries.

Dolly Varden in South Teigen Creek were longer and heavier compared to its tributaries, North Treaty Creek and its tributaries. Length classes present in South Teigen tributaries tend to be smaller, with fewer larger length classes, compared to South Teigen Creek. These results support previous assessments that the tributaries provide the majority of fry (0+) and parr (1+) rearing habitat within South Teigen watershed. Length classes present in North Treaty tributaries tend to be smaller, with fewer larger length classes, compared to North Treaty Creek. Although this shift was of a smaller magnitude then in South Teigen watershed, it supports previous assessments that North Treaty Creek provides suitable rearing habitat for Dolly Varden fry and parr. Length class modes are similar between watersheds, with approximate length ranges of 25 to 45 mm for fry, 45 to 70 mm for parr, 70 to 85 mm for 2+ fish, and 85 to 105 mm for 3+ fish. The largest fish caught was 210 mm.

Dolly Varden densities are greater in North Treaty Creek (99.34 fish per 100 m^2; standard error (SE) 17.21) compared to South Teigen Creek (8.84 fish per 100 m^2; SE 1.18); however, variability is greater in North Treaty Creek. Dolly Varden densities are greater in North Treaty tributaries (50.06 fish per 100 m^2; SE 3.12) compared to South Teigen Creek (29.94 fish per 100 m^2; SE 2.06), for sites assessed with channel gradients less than 5%.

Wetlands are present within South Teigen and North Treaty watersheds. All wetlands are dominated by sand/fines substrate with gravels as sub-dominant. All wetlands are dominated by pool cover type with instream vegetation (*Carex spp*.) and overhanging vegetation as sub-dominant cover types. All wetlands have tall shrub riparian vegetation, except wetland ST-W1.

All wetlands possess good rearing habitat. Wetland NT-W1 possesses abundant overwintering habitat with water depths greater than 1.5 m present in some areas; however, a beaver dam is present in the wetland, which restricts fish passage and use. All wetlands possessed no spawning habitat, due to the fine substrates.

3. Habitat Evaluation Procedures and Habitat Budget

3.1 HABITAT EVALUATION PROCEDURE

The Habitat Evaluation Procedure (HEP) is a tool for developing habitat budgets for compensation planning, and it has been used widely in Canada (e.g., Diavik 1998; Dillon Consulting Ltd. 2002; RL&L/Golder 2003; Rescan 2005, 2007; AMEC 2008). The HEP approach has two advantages. First, it provides an objective method to characterize the quality or importance of affected habitats to fish species and aquatic resources. Second, it allows standardization of habitat quality ratings relative to other habitats that have different physical characteristics (e.g., riffle-pool versus wetland). This facilitates comparisons among habitat types and ultimately allows affected habitats to be evaluated as a single group for the compensation calculation.

For the Plan, the HEP will be used to construct a habitat budget (US Fish and Wildlife Service 1980). The HEP is a generalized procedure for assessing habitat suitability in streams and lakes. By multiplying habitat area (measured in m^2) by a Habitat Suitability Index (HSI, no units), the HEP produces HUs that are indices of both habitat quantity and quality. HUs are the currency of habitat budgeting and compensation planning.

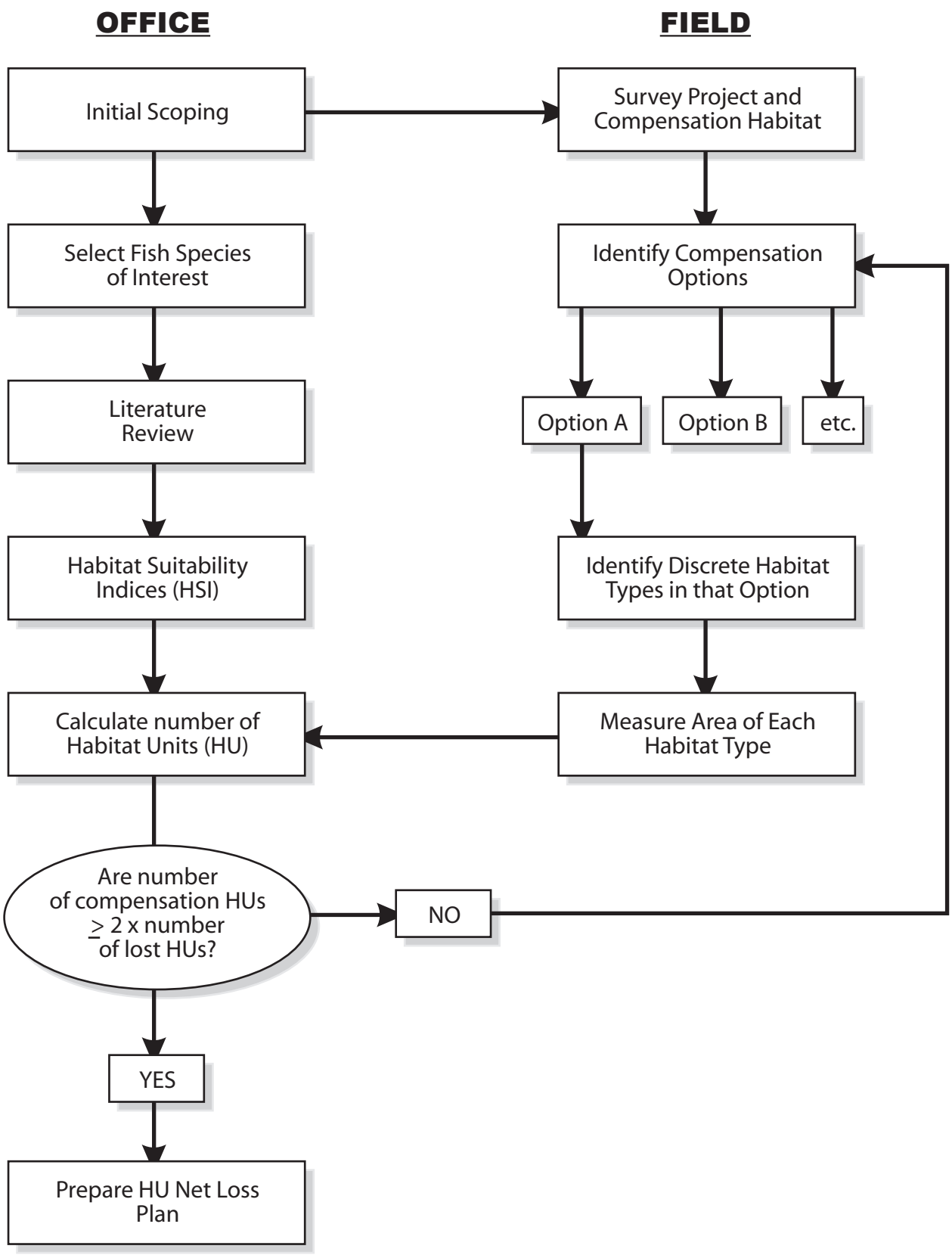
Where the Project causes an impact to habitat, affected habitats are quantified and characterized in terms of their importance to fish. The Plan is based on the type of habitat affected. Compensation of lost habitat for created habitat is based upon the estimation of HUs lost. Overall, the HEP is based upon the suitability of a habitat type to support different life history stages of a species. HSIs, derived primarily from scientific literature, are used to quantify the suitability of the habitat type to support each critical life history stage.

There are four key steps in the HEP that are followed in the development of a fish habitat compensation plan (Figure 3.1 1):

- initial scoping of the study area and relevant species present in the study area; this includes brief reviews of the life histories of relevant species, followed by justification of the decision to base habitat compensation planning on certain species habitat requirements;
- use and/or development of HSI models for impacted and target fish species;
- habitat assessment of the Project area and of the proposed compensatory works; and
- preparation of a budget of lost and gained HUs.

The ratio of compensation area to impacted habitat area is dependent on the value of the habitat destroyed as well as the value of the proposed compensation habitat. For example, high quality habitat may require additional compensation area in order to ensure no net loss of productive capacity. Alternatively, low quality habitat may be replaced with a smaller area of higher quality habitat. The value of the habitat is multiplied by the area of the compensation or impacted habitat to create Hus, which are used to construct the habitat budget.

Multiple species may benefit from compensation projects. Where multiple species are known to benefit from a compensation project, the primary target species was selected for habitat unit calculation.



Links between Steps in the Calculation of Habitat Units

FIGURE 3.1-1

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For the Plan, the habitat unit budget assumes a 2:1 ratio of compensatory habitat to impacted habitat, which is a typical ratio requested by DFO. In other words, the budget is designed to provide at least two HUs of compensation habitat for every HU of destroyed habitat.

3.2 HABITAT SUITABILITY INDICES MODELS

3.2.1 Species Scoping

Dolly Varden is the only species present in the proposed TMF footprint. A search of the scientific literature found that HSI models are currently available for over 157 species of aquatic and terrestrial animals (US Geological Survey 2010). However, no HSI exist for Dolly Varden, presumably because of a lack of sufficient information on Dolly Varden habitat requirements and because of the wide range of potential habitats that can be exploited by Dolly Varden.

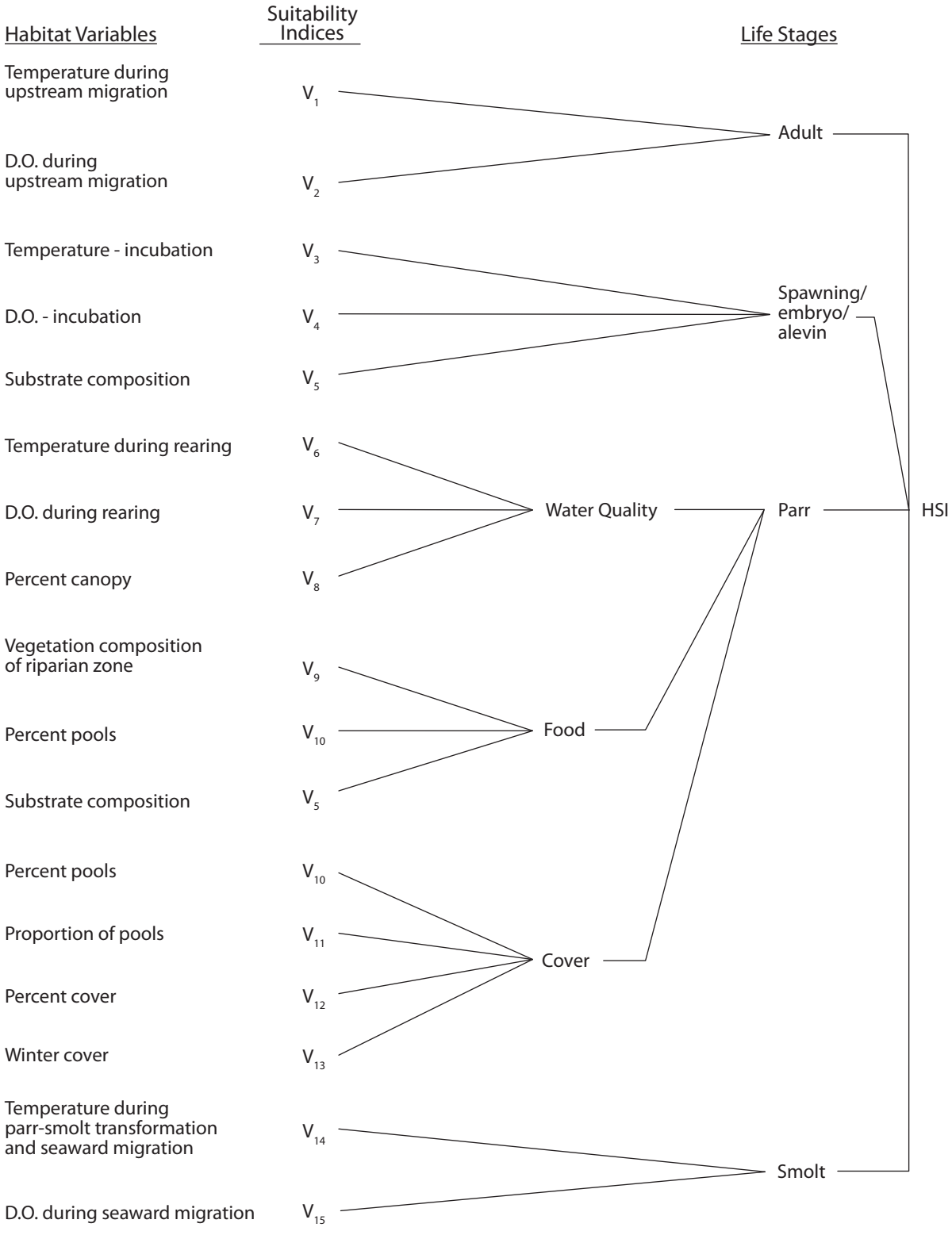
Keeley and Slaney (1996) reviewed the spawning and rearing characteristics of habitat for stream-dwelling salmonids and found only two papers that described Dolly Varden rearing habitat: Dolloff and Reeves (1990) and Bugert, Bjornn, and Meehan (1991). No scientific papers described Dolly Varden spawning habitat. Over the last 10 years, more papers have been published on Dolly Varden, not enough, however, to allow the development of a full HSI model.

A generalized HSI model for Dolly Varden was adopted for this Plan (Rescan 2007). This model was peer reviewed by regulators and approved during the review process of a proposed neighbouring mine, Galore Creek Mine (Rescan 2007). The members of the Galore Creek technical fisheries working group who participated in meetings and reviews of the Galore Creek Fish Habitat Compensation Plan, including the Dolly Varden HSI model, were: Karen Diemert (MOE), Pat Lim (DFO), Gordon Glova (LGL), Jack Love (DFO), Paul Christensen (DFO), and Eero Karanka (DFO). Their acceptance of the Galore Creek Fish Habitat Compensation Plan constitutes review and approval of the Dolly Varden HSI model. The Dolly Varden model was primarily based upon comparison with existing HSI models for other stream dwelling salmonids, published scientific papers (Appendix 3.2-1), project-specific data (if applicable), and field observations. Details regarding the development of the Dolly Varden HSI model are summarized in the following sections.

Dolly Varden are the only species present in the TMF; however, the proposed compensation projects were designed to benefit multiple salmonid species. Therefore, coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Oncorhynchus mykiss*), and chinook salmon (*Oncorhynchus tshawytscha*) were identified for comparisons of HSI models and for preparation of habitat budgets for selected species. HSI models exist for all of these species (McMahon 1983; Raleigh et al. 1984; Raleigh, Miller, and Nelson 1986). All three models are based on a comprehensive review of the published scientific literature and are described as being applicable to streams within and surrounding the fisheries study area.

3.2.2 Coho Salmon Habitat Suitability Index

McMahon's (1983) HSI model for coho salmon included 15 variables (Figure 3.2-1). For each habitat variable, a graph was provided that showed how the suitability index (SI), a unitless number from 0 (unsuitable) to 1 (optimal), changed over that variable. For example, the composition of spawning substrate (i.e., variable V5 in Figure 3.2-1) was shown to have a SI of 0.0 at 0% gravel and cobble (where gravel was defined as particles with diameters of 10 to 60 mm and cobble with diameters of 61 to 250 mm), and an SI of 1.0 at 60 to 100% gravel and cobble (Figure 3.2-2). This plot was accompanied by a plot of SI on percent fines (defined as particles less than 6 mm in diameter), which showed SI falling from 1.0 at 0% fines to 0.0 at 50% fines (Figure 3.2-2). Either plot can be used alone, depending on what is measured during a habitat survey, or together, in which case an average SI is calculated from the two plots.



(Source: McMahon, 1983)

Tree Diagram Showing how Habitat Variables were Linked into an HSI for Coho Salmon

FIGURE 3.2-1

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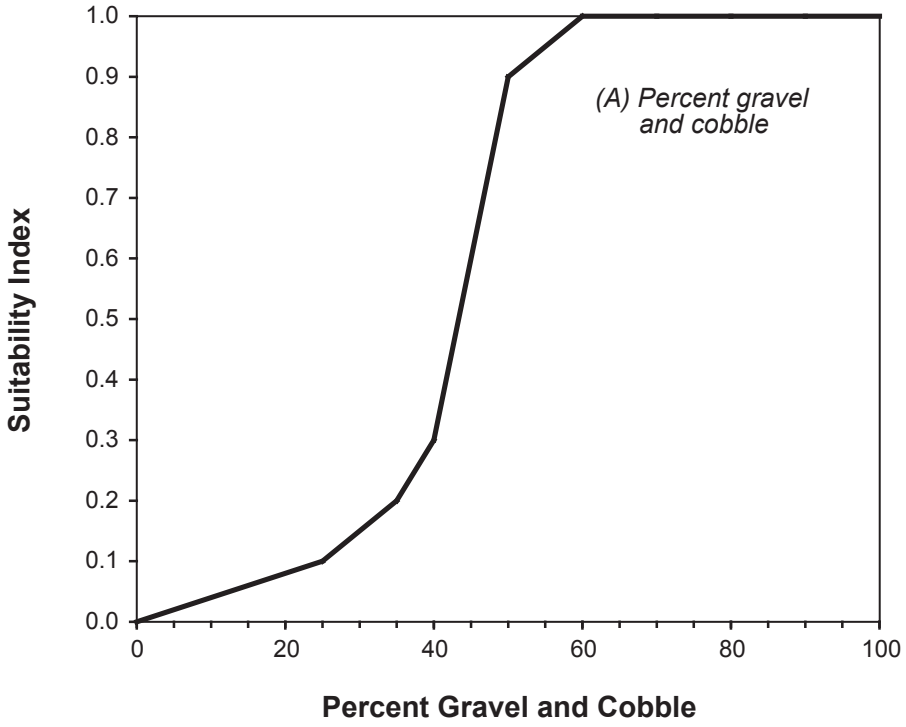
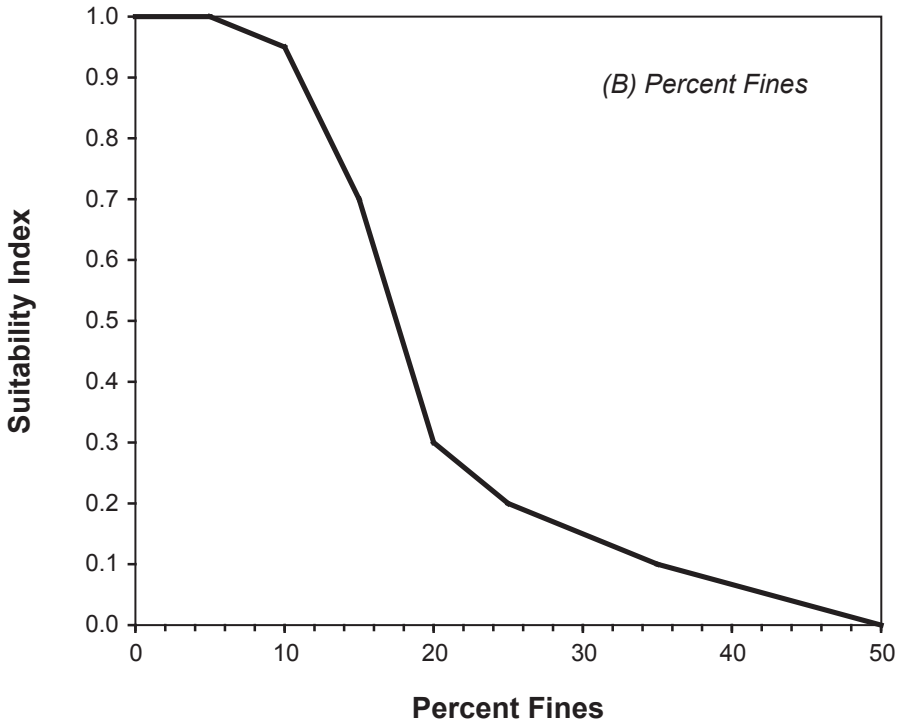




(Source: McMahon, 1983)

Plots of Suitability Indices for Coho Salmon Spawning Substrate on Percent Gravel and Cobble and Percent Fines

FIGURE 3.2-2

McMahon's (1983) HSI model assumed that a stream's carrying capacity for any life stage of coho salmon was limited by the lowest SI score for any of the variables associated with that life stage. For example, if the percent fines in the spawning substrate for a stream reach were greater than 50%, then the HSI for that reach would have a value of 0.0 and the habitat would be classified as unsuitable for spawning, regardless of the SI values for other variables associated with spawning habitat.

This limiting-factor approach was used in all of the HSI models, mainly because it is the most conservative approach. The limiting-factor approach assumes that all variables are equally important, which may not be the real case. However, since the calculations of habitat lost and gained use the same approach, it may be assumed that any inherent errors cancel each other out.

The 15 variables for the coho salmon HSI model were reduced to five-category tables (i.e., excellent to unsuitable) for each of the four key life history stages (Table 3.2-1). The four life stages recognized for coho salmon were (McMahon 1983):

- migration of pre-spawning adults to the spawning grounds during spring, summer, or fall;
- spawning, egg incubation, and emergence of fry;
- rearing of fry and juveniles during spring, summer, and fall; and
- overwintering of fry and juveniles in refuge habitat.

Table 3.2-1. Habitat Suitability Indices for Coho Salmon in Stream Environments

Habitat Variable	V_X	Excellent	Above Average	Average	Below Average	Unsuitable
HSI value		0.80 to 1.00	0.60 to 0.79	0.40 to 0.59	0.20 to 0.39	0.00 to 0.19
				Adult Migration		
Max. temperature (°C)	V_1	5 to 10	10 to 12	12 to 13.5	13.5 to 16	> 16
Min. diss. oxygen (mg/L)	V_2	> 6.5	5.5 to 6	5 to 5.5	4.7 to 5.2	< 4.7
				Spawning/Incubation/Emergence		
Max. temperature (°C)	V_3	4.5 to 13.5	4 to 13.5	3.5 to 14.5	3 to 15	0 to > 18
Min. diss. oxygen (mg/L)	V_4	> 65	60 to 65	55 to 60	45 to 55	< 55
Substrate (% gravel/cobble)	V_5	> 50	45 to 50	40 to 45	35 to 40	< 35
Substrate (% fines)	V_5	< 15%	15 to 17.5	17.5 to 20	20 to 25	> 25
				Rearing		
Max. temperature (°C)	V_6	7.5 to 14.5	7 to 15	6 to 17	5 to 20	4 to 24
Min. diss. oxygen (mg/L)	V_7	> 6.5	6 to 6.5	5.5 to 6	4.5 to 5.5	< 4.5
Substrate (% gravel/cobble)	V_5	> 50	45 to 50	40 to 45	35 to 40	< 35
Substrate (% fines)	V_5	< 15%	15 to 17.5	17.5 to 20	20 to 25	> 25
Percent canopy	V_8	35 to 85	30 to 90	20 to 100	0 to 20	none
Riparian zone index	V_9	> 125	100 to 125	75 to 100	50 to 75	0 to 50
Percent pools	V_{10}	35 to 70	30 to 75	25 to 80	20 to 90	0 to 15
Percent pools with canopy	V_{11}	55 to 100	50 to 55	35 to 50	0 to 35	none
Percent cover	V_{12}	30 to 50	25 to 30	20 to 25	0 to 20	none
				Overwintering		
Max. temperature (°C)	V_{14}	7 to 11	6 to 11	5 to 12	4 to 13	12 to 16
Winter cover	V_{13}	25 to 50	20 to 25	12.5 to 20	0 to 12.5	none

Source: McMahon (1983).
Riparian zone index = 2 × (% cover by trees and shrubs) + (% cover by grasses and forbs) + (% conifer cover).
V_X are the habitat variables shown in Figure 3.2-1.

These four life stages differ from McMahon (1983) for coho salmon (adult, spawning/embryo/alevin, parr and smolt) because they include an overwintering stage. Research since the early 1980s has shown that the presence or absence of overwintering habitat is a key factor in the survival of salmonids in small coastal streams during the long, dark, and cold winters of northern BC (e.g., Sandercock 1991; Cunjak 1995). Winters are characterized by low food abundance, highly variable flows and, in the smaller streams, extreme events such as debris slides and the formation of ice jams. During winter, stream-resident juvenile salmonids actively seek out deep, sheltered pools and side channels with canopy cover that provide stable, safe environments.

3.2.3 Rainbow Trout Habitat Suitability Index

Raleigh et al.'s (1984) HSI model for rainbow trout included a total of 18 variables and was organized in a slightly different manner than the model for coho salmon (Figure 3.2-3). As with the coho model, the carrying capacity of a stream for a life stage of rainbow trout was assumed to be limited by the lowest SI score for any of the variables associated with that life stage.

There are more options in the SI plots for rainbow trout than for coho salmon because of the greater plasticity of rainbow trout life history.

The 18 variables for rainbow trout HSI model were reduced to 14 variables in five-category tables (i.e., excellent to unsuitable) for each of the four key life history stages (Table 3.2-2). Four life stages were recognized for rainbow trout:

- adults;
- spawning, egg incubation, and emergence of fry;
- rearing of fry during spring, summer, and fall; and
- rearing of juveniles during spring, summer, and fall.

3.2.4 Chinook Salmon Habitat Suitability Index

Raleigh, Miller, and Nelson's (1986) HSI model for chinook salmon included 18 variables (Figure 3.2-4). As with the coho model, the carrying capacity of a stream for a life stage of chinook salmon was assumed to be limited by the lowest SI score for any of the variables associated with that life stage.

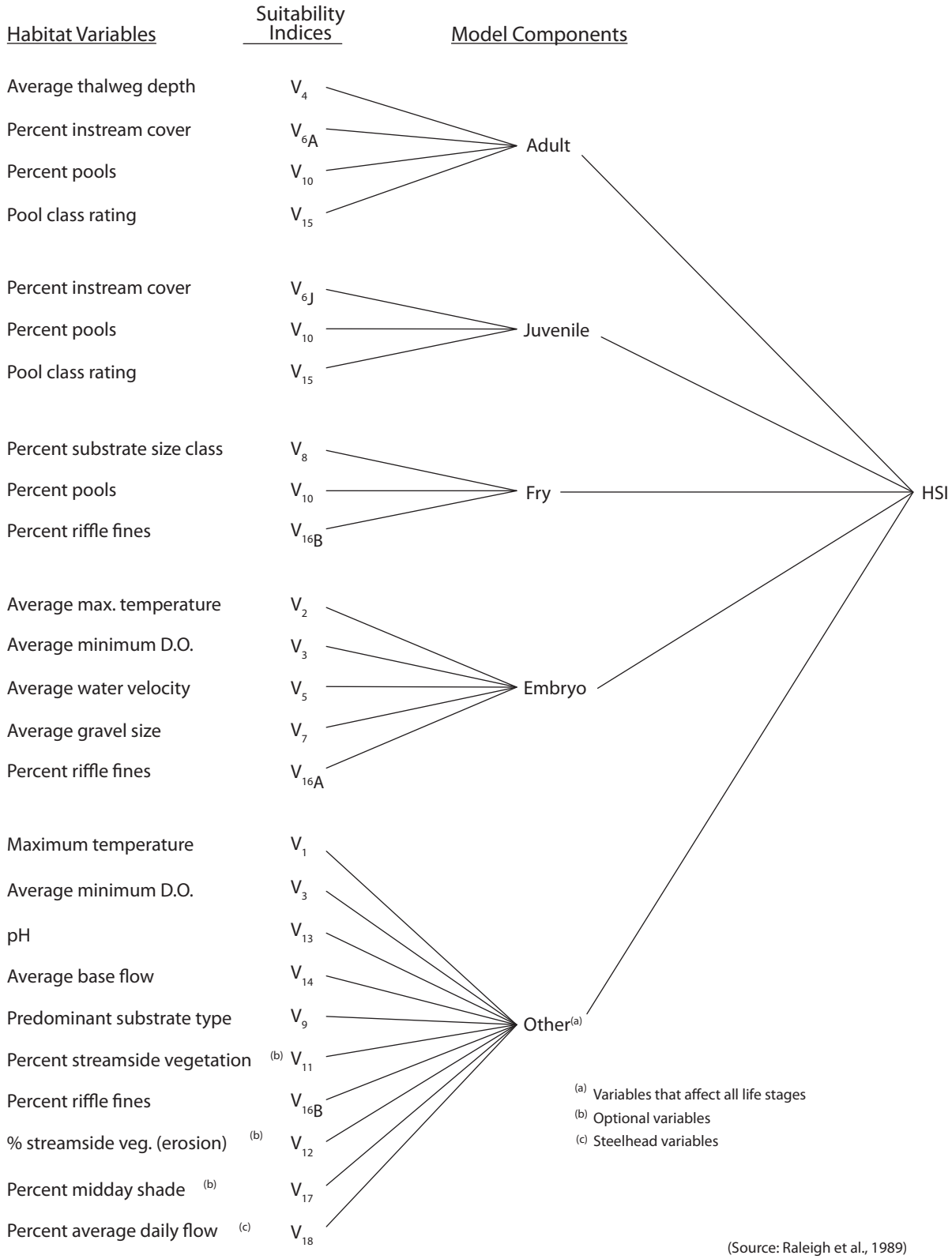
The 18 variables for the chinook salmon HSI model were reduced to 14 variables in five-category tables (i.e., excellent to unsuitable) for each of the three key life history stages (Table 3.2-3). The three life stages recognized for chinook salmon were:

- adults;
- spawning, egg incubation, and emergence of fry; and
- rearing of juveniles during spring, summer, and fall.

3.2.5 Dolly Varden Habitat Suitability Index

3.2.5.1 Habitat Suitability Index Model Development

A complete literature review of Dolly Varden habitat preferences and studies are presented in Appendix 3.2-1. To develop the Dolly Varden HSI model, comparisons with various HSI models and suitability curves were completed for other species stream dwelling salmonids using a weight of evidence approach. Three stream dwelling species were compared in this process. These species include rainbow trout, coho salmon, and chinook salmon. The results of the comparisons are discussed below. Furthermore, the model results are consistent with the literature review of Dolly Varden habitat preferences, studies, and field observations.



Tree Diagram Showing how Habitat Variables were Linked into an HSI for Rainbow Trout

FIGURE 3.2-3

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Table 3.2-2. Habitat Suitability Indices for Rainbow Trout in Stream Environments

Habitat variable	V_X	Excellent	Above Average	Average	Below Average	Unsuitable
HSI value		**0.80 to 1.00**	**0.60 to 0.79**	**0.40 to 0.59**	**0.20 to 0.39**	**0.00 to 0.19**
Adult						
Max. temperature (˚C)	V_1	7 to 20	5 to 22	3 to 23	2 to 24	0 to 25
Min. diss. oxygen (mg/L)	V_3	5.5 to 7	4.5 to 5.5	4 to 4.5	3.5 to 4	<3
Average thalweg depth (cm)	V_4	35 to 45	30 to 35	25 to 30	20 to 25	<10
Percent adult cover	V_6	14 to 24	8 to 14	4 to 8	0 to 4	none
Percent pools	V_{10}	20 to 85	12.5 to 90	5 to 100	none	none
pH	V_{13}	6 to 8.5	6 to 8.5	5.5 to 9.0	5.5 to 9.2	5.5 to 9.4
Base flow as % of MAF	V_{14}	40 to 100	30 to 40	20 to 30	10 to 20	0 to 10
Pool class rating (A/B/C)	V_{15}	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.33/0.33/0.33
Dominant substrate (A/B/C)	V_9	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Percent riffle fines	V_{16}	5 to 15	15 to 20	20 to 30	30 to 60	>60
Spawning/Incubation/Emergence						
Max. temperature (˚C) eggs	V_2	5 to 15	4 to 16	3 to 17	2 to 18	0 to 20
Min. diss. oxygen (mg/L)	V_3	5.5 to 7	4.5 to 5.5	4 to 4.5	3.5 to 4	<3
Water velocity (cm/sec)	V_5	25 to 75	20 to 80	15 to 85	12 to 85	10 to 90
Average gravel size (cm)	V_7	1 to 7.5	0.5 to 8	0.3 to 8.5	0.2 to 9	0 to >10
pH	V_{13}	6 to 8.5	6 to 8.5	5.5 to 9.0	5.5 to 9.2	5.5 to 9.4
Percent riffle fines	V_{16}	5 to 15	15 to 20	20 to 30	30 to 60	>60
Fry Rearing						
Max. temperature (˚C)	V_1	7 to 20	5 to 22	3 to 23	2 to 24	0 to 25
Min. diss. oxygen (mg/L)	V_3	5.5 to 7	4.5 to 5.5	4 to 4.5	3.5 to 4	<3
Percent substrate size	V_8	8 to 10	6 to 8	4 to 6	2 to 4	0 to 2
Dominant substrate (A/B/C)	V_9	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Percent pools	V_{10}	20 to 85	12.5 to 90	5 to 100	none	none
pH	V_{13}	6 to 8.5	6 to 8.5	5.5 to 9.0	5.5 to 9.2	5.5 to 9.4
Base flow as % of MAF	V_{14}	40 to 100	30 to 40	20 to 30	10 to 20	0 to 10
Percent riffle fines	V_{16}	10 to 25	25 to 35	35 to 45	45 to 60	>60
Juvenile Rearing						
Max. temperature (˚C)	V_1	8 to 18	5 to 19	3 to 20	2 to 21	0 to 21
Min. diss. oxygen (mg/L)	V_3	5.5 to 7	4.5 to 5.5	4 to 4.5	3.5 to 4	<3.5
Percent juvenile cover	V_6	7 to 14	4 to 7	2 to 4	0 to 2	none
Percent substrate size	V_8	8 to 10	6 to 8	4 to 6	2 to 4	0 to 2
Dominant substrate (A/B/C)	V_9	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Percent pools	V_{10}	20 to 85	12.5 to 90	5 to 100	none	none
Pool class rating (A/B/C)	V_{15}	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.33/0.33/0.33
pH	V_{13}	6 to 8.5	6 to 8.5	5.5 to 9.0	5.5 to 9.2	5.5 to 9.4
Base flow as % of MAF	V_{14}	40 to 100	30 to 40	20 to 30	10 to 20	0 to 10
Percent riffle fines	V_{16}	10 to 20	20 to 35	35 to 45	45 to 60	>60

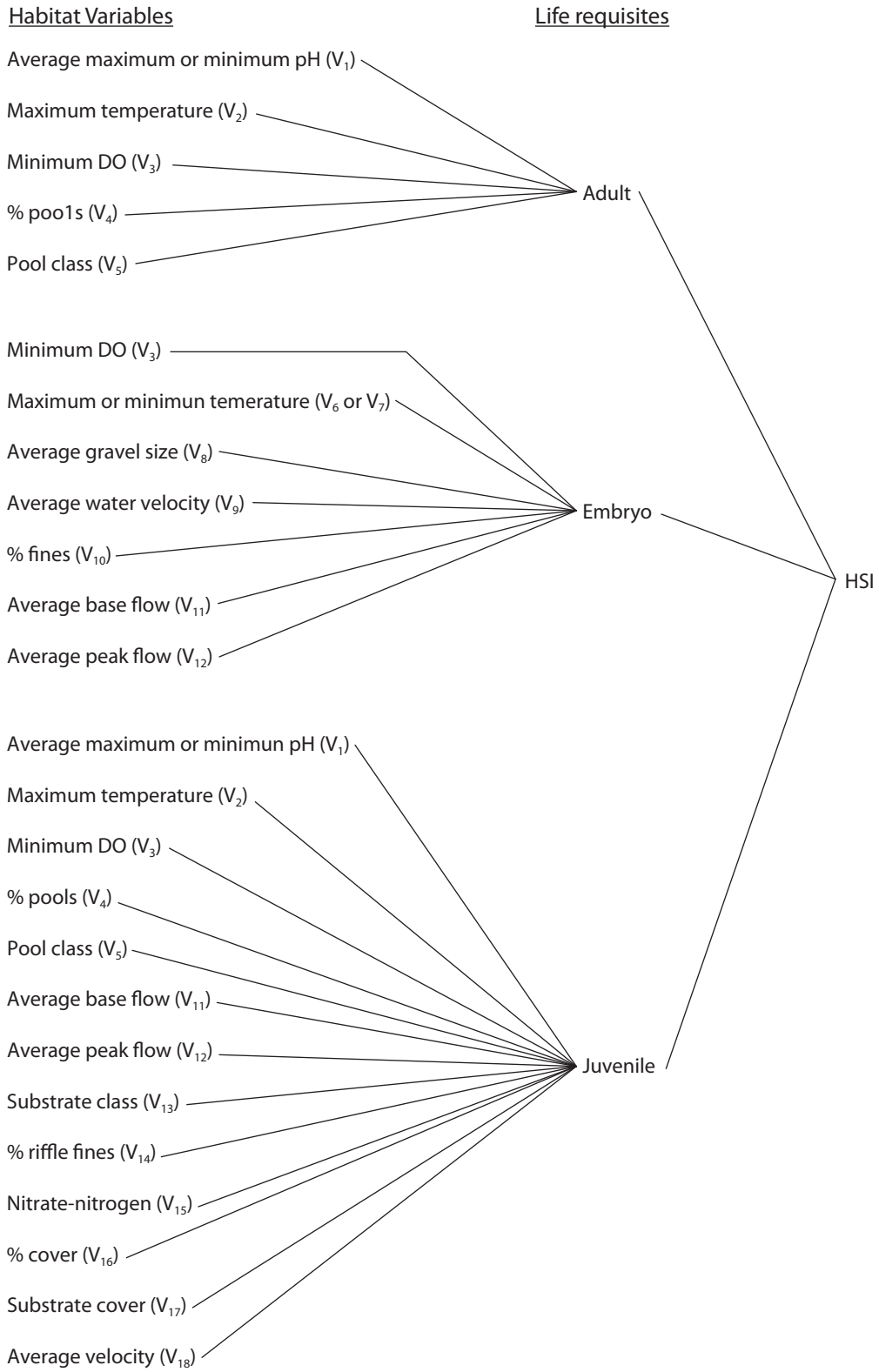
Source: Raleigh et al. (1984).

V_X are the habitat variables shown in Figure 3.2-3.

MAF = Mean Annual Flow.

Substrate rating (V_9): A = cobble or boulders or small vegetation; B = silt, gravel, cobble, boulders in equal amounts; and C = fines, bouldes and bedrock dominate.

Pool rating: A = large, deep (>1.5 m), 30% obscure; B = moderate size and depth, 5 to 30% obscure; and C = small, shallow, clear.



Tree Diagram Showing how Habitat Variables were Linked into an HSI for Chinook Salmon

FIGURE 3.2-4

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Table 3.2-3. Habitat Suitability Indices for Chinook Salmon in Stream Environments

Habitat variable	V_X	Excellent	Above average	Average	Below Average	Unsuitable
HSI value		**0.80 to 1.00**	**0.60 to 0.79**	**0.40 to 0.59**	**0.20 to 0.39**	**0.00 to 0.19**
Adult						
Average max. or min. pH	V1	7.5 to 8.2	6.3 to 7.4 ; 8.3 to 8.4	6.0 to 6.2 ; 8.5 to 8.6	5.7 to 5.9 ; 8.7 to 8.8	<5.7 ; >8.8
Temperature	V2	6 to 14	5 to 5.9 ; 15.1 to 17	3 to 4.9 ; 17.1 to 19	2 to 2.9 ; 19.1 to 21.5	<2 ; >22
Minimum Dissolved Oxygen	V3					
	< 5 °C	7.5 to 9.0	6.5 to 7.4	5.0 to 6.4	4.0 to 4.9	2.5 to 3.9
	5 to 10 °C	8.0 to 9.0	7.3 to 7.9	6.5 to 7.2	5.5 to 6.4	4.5 to 5.4
	> 10 °C	11.5 to 13.0	10.0 to 11.4	8.0 to 9.9	6.5 to 7.9	4.5 to 6.4
Percent Pools	V4	30 to 59	20 to 29 ; 60 to 79	10 to 19 ; 80 to 89	0 to 9 ; 90 to 100	none
Pool class rating (A/B/C)	V5	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Spawning/Incubation/Emergence						
Minimum Dissolved Oxygen	V3					
	< 5 °C	7.5 to 9.0	6.5 to 7.4	5.0 to 6.4	4.0 to 4.9	2.5 to 3.9
	5 to 10 °C	8.0 to 9.0	7.3 to 7.9	6.5 to 7.2	5.5 to 6.4	4.5 to 5.4
	> 10 °C	11.5 to 13.0	10.0 to 11.4	8.0 to 9.9	6.5 to 7.9	4.5 to 6.4
Max. or min. temperature (°C)	V7	5.5 to 15.0	5.0 to 5.4 ; 15.1 to 15.5	4.0 to 4.9 ; 15.6 to 16	3.5 to 3.9 ; 16.4 to 17	<3.5 or >17
Percent Spawning Gravel	V8					
	A	> 2	1.0 to 2.0	0.5 to 0.9	0.2 to 0.4	<0.1
	B	none	>3	1.3 to 3.0	0.5 to 1.2	<0.4
Average water velocity (cm/s)	V9	30 to 85	26 to 29 ; 86 to 95	25 to 25.9 ; 96 to 105	24 to 24.9 ; 106 to 115	<24 ; >115
Percent fines	V10					
	silt	5 to 8	9 to 10	11 to 12	13 to 15	16 to 30
	sand	5 to 15	16 to 21	22 to 25	26 to 30	27 to 30
Base flow as % of MAF	V11	45 to 100	30 to 44	22 to 29	10 to 21	0 to 9
Peak flow as % of MAF	V12	1.5 to 4.2	1.1 to 1.5 ; 4.3 to 5	<1.1 ; 5 to 5.5	5.5 to 6	>6
Juvenile Rearing						
Temperature	V2	10 to 19	7 to 9.9 ; 19.1 to 20.5	5 to 6.9 ; 20.6 to 22	2.5 to 4.9 ; 22.1 to 22.5	<2.5 ; >22.5
Minimum Dissolved Oxygen	V3					
	< 5 °C	7.5 to 9.0	6.5 to 7.4	5.0 to 6.4	4.0 to 4.9	2.5 to 3.9
	5 to 10 °C	8.0 to 9.0	7.3 to 7.9	6.5 to 7.2	5.5 to 6.4	4.5 to 5.4
	> 10 °C	11.5 to 13.0	10.0 to 11.4	8.0 to 9.9	6.5 to 7.9	4.5 to 6.4
Percent Pools	V4	30 to 59	20 to 29 ; 60 to 79	10 to 19 ; 80 to 89	0 to 9 ; 90 to 100	none
Pool class rating (A/B/C)	V5	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Base flow as % of MAF	V11	45 to 100	30 to 44	22 to 29	10 to 21	0 to 9
Peak flow as % of MAF	V12	1.5 to 4.2	1.1 to 1.5 ; 4.3 to 5	<1.1 ; 5 to 5.5	5.5 to 6	>6
Substrate class	V13	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Percent riffle fines	V14	10 to 20	21 to 30	31 to 40	41 to >50	none
Percent cover	V16	16 to 100	12 to 15	8 to 11	4 to 7	<3

MAF = Mean Annual Flow.

Source: Raleigh et al. (1986).

V_X are the habitat variables shown in Figure 3.2-4

Substrate rating (V_{13}): A = cobble or boulders or small vegetation; B = silt, gravel, cobble, boulders in equal amounts; and C = fines, bouldes and bedrock dominate.

Pool class rating (V5): A = large, deep (>1.5 m), 30% obscure; B = moderate size and depth, 5 to 30% obscure; and C = small, shallow, clear

Number of Life Stages

Comparison of the published HSI models for coho salmon, chinook salmon, and rainbow trout showed that each model has at least three life history stages (Table 3.2-4). Since, there is no smolt stage for the freshwater-resident Dolly Varden of the study area, the appropriate life stages are adult, embryo, fry, and parr (Table 3.2-5).

Number of Habitat Classes

The number of habitat variables ranges from a minimum of 16 for coho salmon to a maximum of 18 for rainbow trout, perhaps reflecting the amount of information available for each species. Professional judgement may also play a role in these differences. All habitat variables can be grouped into nine classes: substrate, cover, flow, depth, velocity, temperature, dissolved oxygen, pH, and water quality. Therefore, as a first approximation, the Dolly Varden model has to have at least one variable in each of those nine habitat classes.

In recognition of its well-known ability to occupy higher gradient streams than most salmonids, a tenth class (percent gradient) was introduced for Dolly Varden adults, fry, and parr.

Habitat Variables

Substrate is considered important for embryos and juveniles of all three species, although a substrate variable is only listed for adult rainbow trout and not the adults of coho salmon or chinook salmon. Therefore, substrate is considered a relevant variable for Dolly Varden embryos, fry, and parr, but not adults. Four different measurements of substrate quality are used, including predominant substrate type, average gravel size, percent fines, and percent riffle fines. The first three variables are important for feeding of fry and parr, and the last two variables are important for embryo survival. Therefore, two substrate variables are defined for Dolly Varden. Percent substrate type is used for juveniles and is presented as the fraction of substrate from three general size classes: rubble/boulder, gravel, and fines. For example, a substrate classification of 0.50/0.35/0.15 represents 50% boulder, 35% gravel, and 15% fines. Percent fines is used for embryos.

Cover is considered important for adults and juveniles of all three species, but not for embryos (because they are buried in gravel). Six different measurements of cover are used in the various HSI models, including percent cover, percent instream cover, percent substrate cover, percent pools, pool class rating, and percent winter cover. Many of these forms of cover are interrelated and redundant if all were used for the Dolly Varden HSI model; therefore, two cover variables are defined for Dolly Varden: percent instream cover and percent pools.

Riparian cover and habitat are considered important for adults and juveniles of all three species, but not for embryos. Two interrelated measurements, percent canopy, and vegetation of riparian zone, are related to riparian functions. However, many of the other measurements (previously identified as variables for Dolly Varden) are related to riparian functions, such as instream cover in the form of LWD, percent pools from LWD recruitment; water temperature is related to canopy cover and stream shading. Therefore, one riparian variable was defined for Dolly Varden: vegetation index of riparian zone, which is related to the allochthonous inputs from riparian vegetation and reduces redundancy of the variables.

Table 3.2-4. Habitat Variables of Habitat Suitability Index Models for Rainbow Trout, Chinook Salmon and Coho Salmon

Life Stage	Habitat Class	Habitat Variable	Rainbow Trout	Chinook Salmon	Coho Salmon
Adult	Substrate	Predominant substrate type	X	-	-
		Percent riffle fines	X	-	-
	Cover	Percent instream cover	X	-	-
		Percent pools	X	X	-
		Pool classs rating (A/B/C)	X	X	-
	Flow	Average base flow (percent of MAF)	X	-	-
	Depth	Average thalweg depth	X	-	-
	Velocity	-	-	-	-
	Temperature	Maximum temperature	X	X	-
		Temperature during migration	X	-	X
	Diss. oxygen	Average minimum dissolved oxygen	X	X	X
	pH	Average maximum or minimum pH	X	X	-
	Water quality	-	-	-	-
Embryo	Substrate	Average gravel size	X	X	X
		Percent fines	-	X	-
		Percent riffle fines	X	-	-
		Predominant substrate type	X	-	-
	Cover	-	-	-	-
	Flow	Average base flow (percent of MAF)	X	X	-
		Average peak flow (percent of MAF)	-	X	-
	Depth	-	-	-	-
	Velocity	Average water velocity	X	X	-
	Temperature	Average temperature	-	-	X
		Average maximum temperature	X	X	-
	Diss. oxygen	Average dissolved oxygen	-	-	X
		Average minimum dissolved oxygen	X	X	-
	pH	Average maximum or minimum pH	X	-	-
	Water quality	-	-	-	-
Juvenile	Substrate	Average substrate size class	X	X	X
		Predominant substrate type	X	-	-
		Percent riffle fines	X	X	-
	Cover	Percent cover	-	X	X
		Percent instream cover	X	-	-
		Percent substrate cover	-	X	-
		Percent canopy	-	-	X
		Vegetation of riparian zone	X	-	X
		Percent pools	X	X	X
		Pool class rating	X	X	X
		Percent winter cover	-	-	X
	Flow	Average base flow (percent of MAF)	X	X	-
		Average peak flow (percent of MAF)	-	X	-
	Depth	-	-	-	-
	Velocity	Average water velocity	-	X	-
	Temperature	Average temperature	-	-	X
		Maximum temperature	X	X	-
		Temperature during seawater migration	-	-	X
	Diss. oxygen	Average dissolved oxygen	-	-	X
		Average minimum dissolved oxygen	X	X	-
		Average dissolved oxygen during migration	-	-	X
	pH	Average maximum or minimum pH	X	X	-
	Water quality	Concentration of nitrate-nitrogen	-	X	-

Sources: McMahon (1983), Raleigh et al. (1984, 1986).

MAF = Mean Annual Flow.

Substrate rating: A = cobble or boulders or small vegetation; B = silt, gravel, cobble, boulders in equal amounts; and C = fines, bouldes and bedrock dominate.

Pool rating: A = large, deep (>1.5 m), 30% obscure; B = moderate size and depth, 5 to 30% obscure; and C = small, shallow, clear.

Dashes inddicate not applicable

Table 3.2-5. HSI Model for Dolly Varden in Project Area

Life Stage	Habitat Class	Habitat Variable	Units	Rating			
				High	Moderate	Low	Poor
Adult	Stream gradient	Percent stream gradient	%	0 to 4	5 to 9	10 to 14	15 to 19
	Substrate	NA	NA	NA	NA	NA	NA
	Cover	Percent instream cover	%	>20	10 to 19	5 to 9	<5
		Percent pools	%	35 to 70	1-34 and 71-99	none	none
	Riparian	Vegetation index of riparian zone	-	>150	149 to 75	74 to 49	<49
	Flow	Average base flow	% of MAF	50 to 100	35 to 49	20 to 34	0 to 19
	Velocity	NA	NA	NA	NA	NA	NA
	Temperature	Average temperature	˚C	7 to 13	4.5-6.9/13.1-15.6	2-4.5/15.7-18.5	0-1.9/18.6-20
	Dissolved oxygen	Average dissolved oxygen	mg/L	>7	6 to 6.9	5 to 5.9	<5
	pH	Average pH	log units	6.5 to 8.0	6.0-6.4/8.1-8.5	5.5-5.9/8.6-8.9	<5.5 and >9.0
Embryo	Stream gradient	NA	NA	NA	NA	NA	NA
	Substrate	Percent fines	%	<15	15 to 20	20 to 25	>25
	Cover	NA	NA	NA	NA	NA	NA
	Flow	Average base flow	% of MAF	50 to 100	35 to 49	20 to 34	0 to 19
	Velocity	Average velocity	cm/s	30 to 70	20-29 and 71-79	10-19 and 80-89	0-9 and >90
	Temperature	Average temperature	˚C	7 to 13	4.5-6.9/13.1-15.6	2-4.5/15.7-18.5	0-1.9/18.6-20
	Dissolved oxygen	Average dissolved oxygen	mg/L	>7	6 to 6.9	5 to 5.9	<5
	pH	Average pH	log units	6.5 to 8.0	6.0-6.4/8.1-8.5	5.5-5.9/8.6-8.9	<5.5 and >9.0
Fry	Stream gradient	Percent stream gradient	%	0 to 4	5 to 9	10 to 14	15 to 19
	Substrate	Percent gravel and rubble (A/B/C)	%	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
	Cover	Percent instream cover	%	>20	10 to 19	5 to 9	<5
		Percent pools	%	35 to 70	1-34 and 71-99	none	none
	Riparian	Vegetation index of riparian zone	-	>150	149 to 75	74 to 49	<49
	Flow	Average base flow	% of MAF	50 to 100	35 to 49	20 to 34	0 to 19
	Velocity	NA	NA	NA	NA	NA	NA
	Temperature	Average temperature	˚C	7 to 13	4.5-6.9/13.1-15.6	2-4.5/15.7-18.5	0-1.9/18.6-20
	Dissolved oxygen	Average dissolved oxygen	mg/L	>7	6 to 6.9	5 to 5.9	<5
	pH	Average pH	log units	6.5 to 8.0	6.0-6.4/8.1-8.5	5.5-5.9/8.6-8.9	<5.5 and >9.0
Parr	Stream gradient	Percent stream gradient	%	0 to 4	5 to 9	10 to 14	15 to 19
	Substrate	Percent gravel and rubble (A/B/C)	%	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
	Cover	Percent instream cover	%	>20	10 to 19	5 to 9	<5
		Percent pools	%	35 to 70	1-34 and 71-99	none	none
	Riparian	Vegetation index of riparian zone	-	>150	149 to 75	74 to 49	<49
	Flow	Average base flow	% of MAF	50 to 100	35 to 49	20 to 34	0 to 19
	Velocity	NA	NA	NA	NA	NA	NA
	Temperature	Average temperature	˚C	7 to 13	4.5-6.9/13.1-15.6	2-4.5/15.7-18.5	0-1.9/18.6-20
	Dissolved oxygen	Average dissolved oxygen	mg/L	>7	6 to 6.9	5 to 5.9	<5
	pH	Average pH	log units	6.5 to 8.0	6.0-6.4/8.1-8.5	5.5-5.9/8.6-8.9	<5.5 and >9.0

Notes:

NA = not applicable, MAF = mean annual flow.

Substrate rating: A = cobble or boulders or small vegetation; B = silt, gravel, cobble and boulders (equal amounts); and C = fines, boulders and bedrock dominate.

Flow is considered important for all three life stages of rainbow trout and chinook salmon, but not for coho salmon. Therefore, flow was included for Dolly Varden. Two interrelated measurements of flow are used: average base flow, defined as the percent of mean annual flow (MAF), and average peak flow, also defined as a percent of MAF. Average base flow (as a percent of MAF) was chosen for Dolly Varden, since both variables are interrelated and redundant if both were used.

Depth is only considered important for adult rainbow trout, defined as the depth of the thalweg—the deepest part of a stream or river. Therefore, depth was not included for Dolly Varden, reducing the total number of habitat classes to eight.

Velocity is considered important for embryos of rainbow trout and chinook salmon and for juveniles of chinook salmon. Therefore, velocity was included in the Dolly Varden HSI model, but only for embryos. In all cases, velocity is measured as average velocity, which is also included in the Dolly Varden model.

Temperature is considered important for all three life stages of all three species; hence it was included in all four life stages of the Dolly Varden model. Four temperature variables were used: average temperature, maximum temperature, temperature during spawning migration, and temperature during seaward migration. Average temperature is used in the Dolly Varden model.

The concentration of dissolved oxygen is considered important for all three life stages of the three species, hence it was included in all four life stages of the Dolly Varden model. Four variables were used: average dissolved oxygen, average minimum dissolved oxygen, and average dissolved oxygen during seaward migration. Average dissolved oxygen is used in the Dolly Varden model.

For all life stages of rainbow trout and for two of the three life stages of chinook salmon, but not for coho salmon, pH is considered important. Therefore, pH is included in the Dolly Varden model. In all cases, pH is expressed as the habitable range.

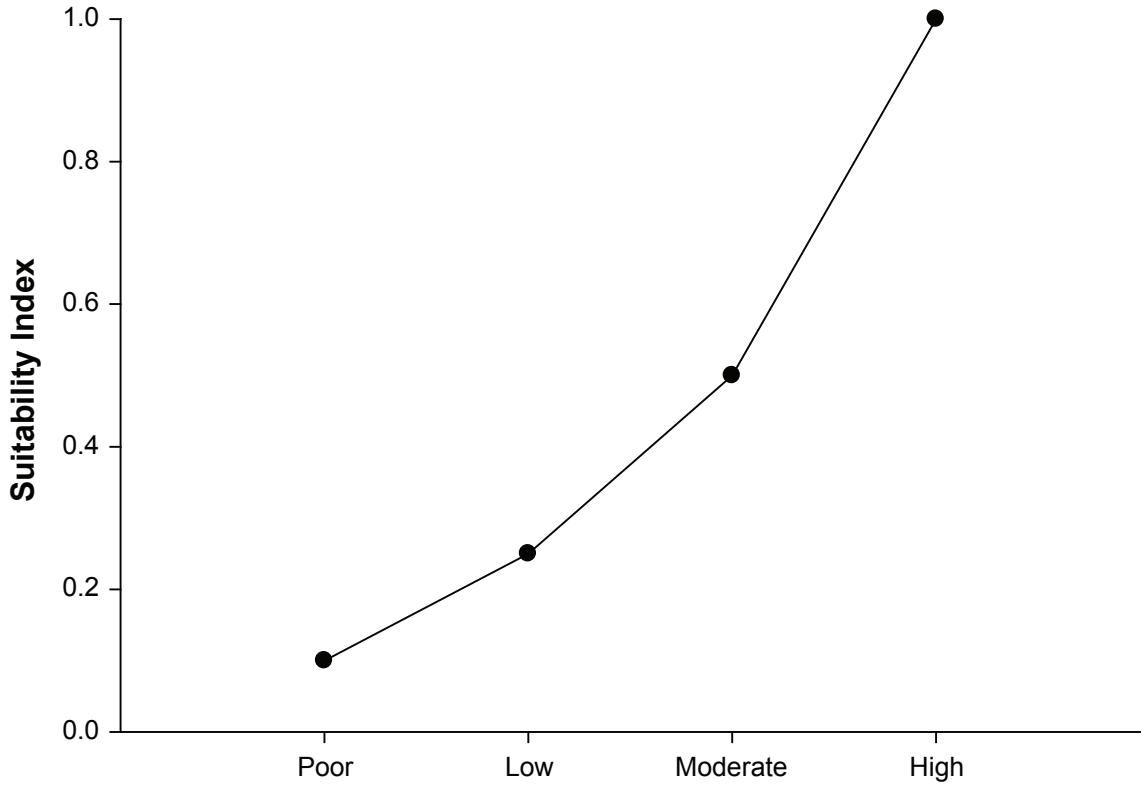
Only one additional water quality variable is used in the three models—average concentration of nitrate-nitrogen—and only for juvenile chinook salmon. Nitrate is not an important habitat variable in natural waters such as the waters KSM Project area, only in waters adversely affected by human wastewater. Therefore, no other water quality variables (other than temperature, dissolved oxygen, and pH) are used in the Dolly Varden model.

In summary, based on the HSI models for rainbow trout, coho salmon, and chinook salmon, a Dolly Varden model was developed that is assumed to have four life stages (adult, embryo, fry, and parr) and eight habitat classes with one to two variables in each class (Table 3.2-5).

3.2.5.2 Habitat Suitability Index Models

Simplified Habitat Suitability Curve

The simplified HSI model for Dolly Varden has only one generalized habitat suitability curve (Figure 3.2-5). The y-axis is an HSI with values from 0 to 1.0, and the x-axis consists of four classes of habitat value: poor, low, moderate and high. Poor habitat is assigned a suitability index value of 0.10, low has a value of 0.25, moderate has a value of 0.50, and high has a value of 1.0.



low complexity	high complexity
high gradient or stagnant	low to moderate gradient
no cover	abundant cover
no pools	abundant pools and eddies
temperature <> optimal range	optimal temperature
high turbidity	clear or low turbidity
low oxygen	high oxygen

Generalized Habitat Suitability Curve for Dolly Varden

FIGURE 3.2-5

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In narrative terms, poor quality habitat is characterized by high gradient, low complexity (e.g., no canopy or instream cover, no LWD, etc.), water temperatures and pH outside the optimal range, and low concentrations of dissolved oxygen. High quality habitat is characterized by moderate gradient and gravel substrate, high complexity (i.e., abundant cover and much LWD), water temperatures and pH within the optimal range, and high concentrations of dissolved oxygen.

The rest of this section provides numerical definitions of those four classes for each of four life stages (adult, embryo, fry, and parr; Table 3.2-5).

Gradient

Information on gradients of Dolly Varden streams is scattered throughout the literature (e.g., Bryant 1984), but few studies sampled a sufficiently wide range of gradients to show preferences. The exception to that rule is a study of 11 headwater streams on Prince of Wales Island in southeast Alaska by Bryant, Zymonas, and Wright (2004), which sampled gradients over a range of 2.4% to 22%. Dolly Varden fry and parr were found over the range of 2.4% to 17%. Adults were not sampled and are assumed in this study to follow the same distribution in regard to gradient as juveniles. The frequency distributions of juvenile density with gradient were similar for both fry and parr, hence those data were pooled. The highest densities of juvenile Dolly Varden were in the gradient range of 5% to 9%. However, Dolly Varden occupy high gradient streams due to inter-specific competition (e.g., coho salmon; Bryant, Zymonas, and Wright 2004).

In the Project area, higher densities of Dolly Varden were present in lower gradient streams without competition for resources with other species (Rescan 2010). Therefore, low gradient of 0 to 4% was defined by this study as high quality, followed in order of decreasing average density by the range of 5 to 9% (moderate), 10 to 14 (low), and 15 to 19% (poor).

Substrate

Percent Fines

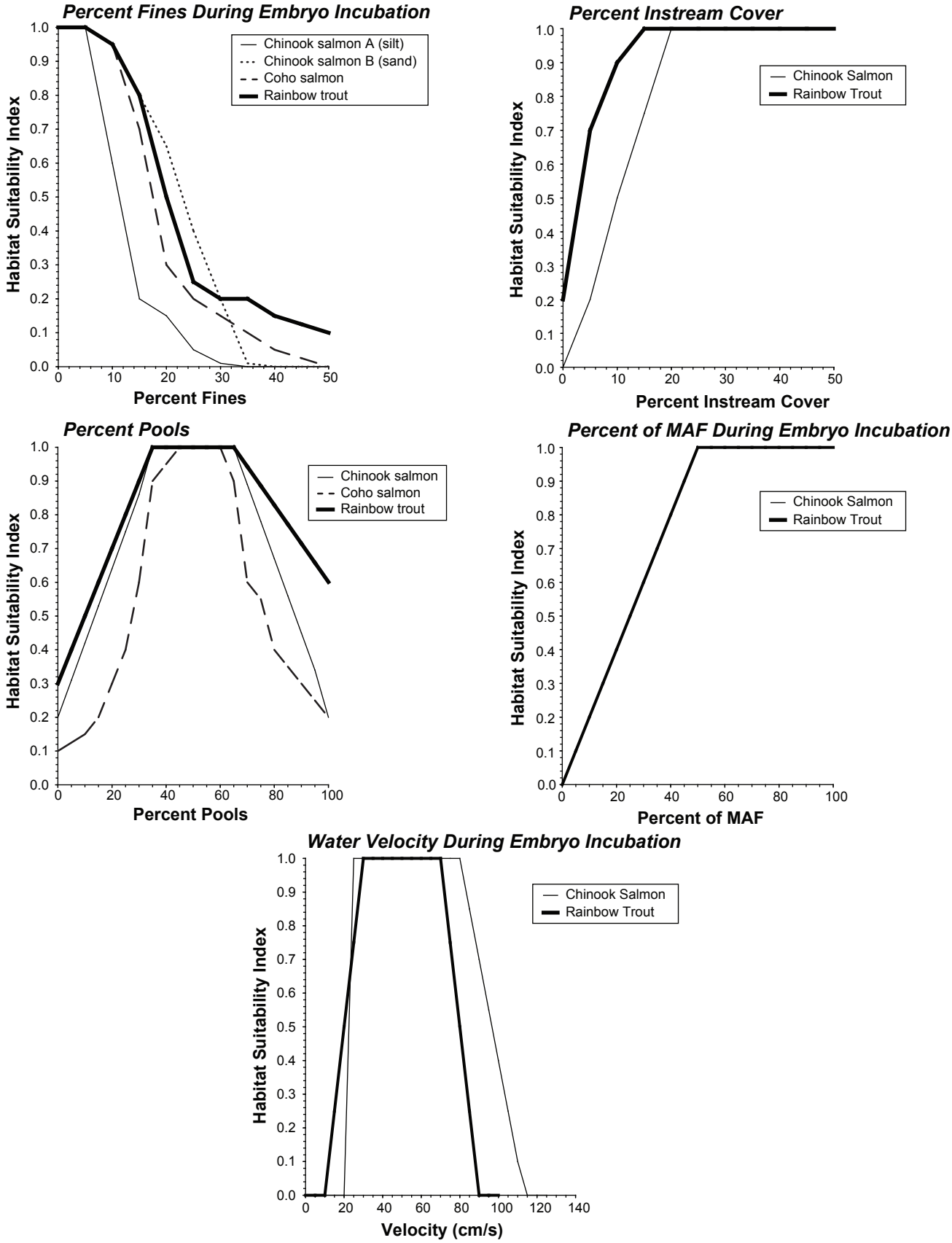
The relationship between suitability indices and percent fines was reported for chinook salmon, coho salmon, and rainbow trout (Figure 3.2-6), based on studies conducted by Burner (1951), Cordone and Kelly (1961), McNeil and Ashell (1964), Koski (1966), McNeil (1968), Orcutt, Pulliam, and Arp (1968), Bjornn (1969), Phillips et al. (1975), Cloern (1976), and Platts, Shirazi, and Lewis (1979). All of the suitability curves showed the same rapid decrease in suitability with increasing percent fines. The curve for coho salmon fell between the curves for rainbow trout and chinook salmon, hence it was adopted for Dolly Varden. Therefore, less than 15% fines is considered high quality, between 15 and 20% is moderate quality, 20 to 25% is low quality, and greater than 25% is poor quality.

Substrate Composition for Juvenile Feeding

Raleigh, Miller, and Nelson's (1986) defined three classes of substrate type in riffle-run areas that support juvenile chinook salmon. Class A consisted of rubble and small boulders with limited amounts of gravel and was assigned a suitability rating of 1. Class B consists of rubble, boulders, and gravel in roughly equal amounts and was assigned a suitability of 0.6. Class C consists of fines, bedrock, or very large boulders and was assigned a suitability of 0.3.

Raleigh et al. (1984) used the same substrate composition for food production for rainbow trout.

McMahon (1983) defined the preferred substrate composition of coho salmon parr as the "percent of rubble and gravel," defined as the sum of the percent of gravel and rubble and the percent of fines (or percent embeddedness, whichever was lower) divided by two. Suitability was assumed to be zero at 0% rubble and gravel, and it rose to a value of 1 at 60% gravel and rubble.



Habitat Suitability and Percent Fines, Percent Instream Cover, Percent Pools, Percent Mean Annual Flow (MAF) and Water Velocity

FIGURE 3.2-6

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Many of these forms of substrate composition are interrelated and redundant if all were used for the Dolly Varden HSI model; therefore, the method used by Raleigh et al. (1984) and Raleign, and Miller, and Nelson (1986) was adopted for Dolly Varden.

Cover

Percent Instream Cover

Both chinook salmon and rainbow trout rearing habitat is considered high quality if at least 20% of the area is classified as cover (Figure 3.2-6), whether from boulders, instream vegetation, cutbanks, or LWD. The most conservative suitability curve is for chinook salmon because it assumes zero suitability at 0% habitat, which was applied to the Dolly Varden HSI model.

Percent Pools

For coho salmon, chinook salmon, and rainbow trout, habitat suitability rises rapidly with the percent of stream areas classified as pool habitat (Figure 3.2-6). Maximum suitability occurs when pools make up between approximately 35 and 70% of stream area. Suitability falls, however, when pool area increases above 70% because of the absence of riffle habitat, which is the most productive habitat in terms of production of insect drift and benthic invertebrates. The suitability curve for chinook salmon falls between the curves for coho salmon and rainbow trout, hence it was chosen for Dolly Varden. That means that high quality in terms of percent pools habitat is defined as 35 to 70%, moderate is defined as the shoulders of the suitability curve (1 to 34% and 71 to 99%), and both low and poor habitat have no pools.

Riparian

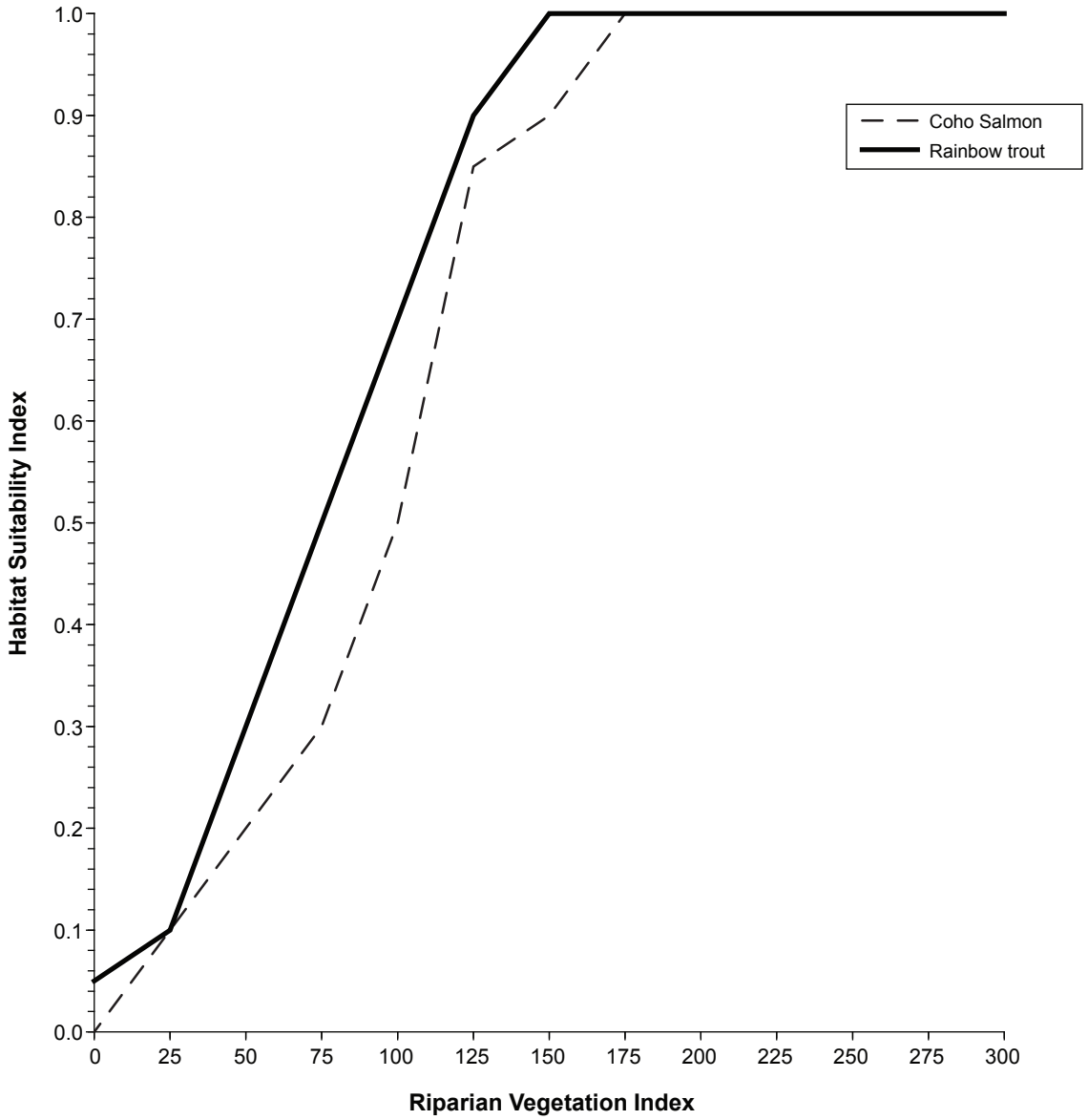
For coho salmon and rainbow trout, habitat suitability rises rapidly with the percent of riparian habitat classified as shrubs or deciduous trees (Figure 3.2-7). Maximum suitability occurs when the riparian index is at 150. Shrubs and deciduous riparian habitat are the most productive habitat in terms of production of allochthonous inputs. The suitability curves for coho salmon and rainbow trout are similar, hence it was chosen for Dolly Varden. That means that high quality in terms of riparian vegetation index is defined as greater than150, moderate is 149 to 75, low is 74 to 49, and poor is less than 49.

Flow

Suitability of habitat for chinook salmon and rainbow trout both increased with the percent of MAF to maximum suitability at 50% MAF and greater (Figure 3.2-6). This single curve was used to define habitat suitability classes for Dolly Varden. High quality habitat is 50 to 100% MAF, moderate is 35 to 39% MAF, low is 20 to 34% MAF, and poor is 0 to 19% MAF.

Water Velocity during Incubation

Suitability of habitat for chinook salmon and rainbow trout embryos followed similar dome shaped relationships with water velocity (Figure 3.2-6). The curve for rainbow trout was chosen for Dolly Varden because the life histories of Dolly Varden and rainbow trout share more commonalities than chinook salmon. Therefore, high quality habitat is defined as 30 to 70 cm/s, moderate is 20 to 29 and 71 to 79 cm/s, low is 10 to 19 and 80 to 89 cm/s, and poor is 0 to 19 and greater than 90 cm/s.



Habitat Suitability and Riparian Vegetation Index

FIGURE 3.2-7

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Temperature

Chinook salmon, coho salmon and rainbow trout showed similar envelopes of HSI for temperature (Figure 3.2-8). Incubating embryos had the lowest temperature ranges and juveniles had the widest ranges with the ranges of migrating adults lying in-between. All three sets of temperature HSI envelopes bracketed the 7 to 13°C range, which was cited by Hicks (2002) as optimum for Dolly Varden, but all showed maxima that exceeded the temperature (16°C) at which Dolly Varden cease eating, and the temperature ranges for some life stages exceeded the lethal temperature (20°C) for Dolly Varden (Takami, Kitano, and Nakano 1997). For all life stages, coho salmon had lower maxima than chinook salmon or rainbow trout.

Based on these data, the Dolly Varden HSI envelopes for temperature HSI are based on a simplified version of the coho salmon model. For all life stages, HSI rose from zero at 0°C to an optimum range from 7 to 13°C and then declined to zero at 20°C (Figure 3.2-8). Therefore, for Dolly Varden high suitability is from 7 to 13°C, moderate is from 4.5 to 6.9°C and from 13.1 to 15.6°C, low is from 2 to 4.5°C and from 15.7 to 18.5°C, and poor is from 0 to 1.9°C and from 18.6 to 20°C.

Dissolved Oxygen

The dissolved oxygen suitability curves for chinook salmon, coho salmon, and rainbow trout are similar (Figure 3.2-9). Suitability is zero until the range of 3 to 4.5 mg/L, whereupon it increases linearly to optimal within the range of 6.5 to 9.0 mg/L.

Based on these data, dissolved oxygen suitability for Dolly Varden is assumed to be zero at 4 mg/L and to increase linearly to a maximum at 7 mg/L. Therefore, high suitability is greater or equal to 7 mg/L, moderate suitability is 6 to 6.9 mg/L, low suitability is 5 to 5.9 mg/L, and poor suitability is less than 5 mg/L.

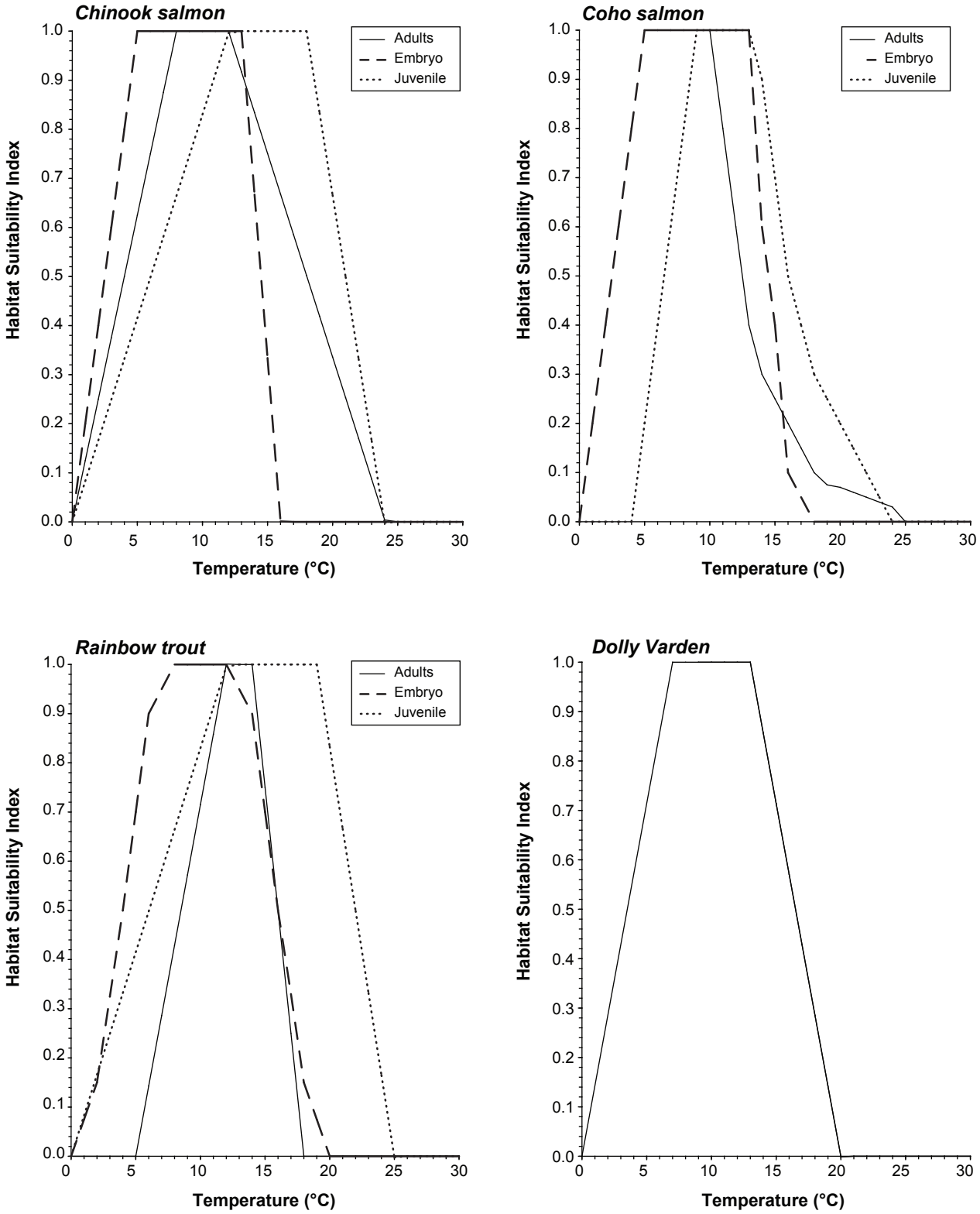
pH

Suitability curves for pH were very similar for chinook salmon and rainbow trout (Figure 3.2-9). Based on these curves, high suitability for Dolly Varden is defined as 6.5 to 8.0, moderate is 6.0 to 6.4 and 8.1 to 8.5, low is 5.5 to 5.9 and 8.6 to 8.9, and poor is less than 5.5 and greater than 9.0.

3.2.6 Wetland Habitat Suitability Index

A search of the scientific literature found that wetland HSI models are not currently available for any salmonid species. HSI models developed for streams are not applicable for wetland habitat. Wetlands and beaver ponds play an important role in the rearing and overwintering of salmonids, in particular coho salmon and Dolly Varden (Slaney and Zaldokas 1997). These species use the same off-channel wetland habitats in the Project study area (Rescan 2009, 2010). Therefore, a generalized habitat suitability curve (similar to the Dolly Varden HSI) was adopted for species in wetland environments (Figure 3.2-10). The y-axis is an HSI with values from 0 to 1.0, and the x-axis consists of five classes of habitat value: poor, low, moderate, above average, and high. Poor habitat is assigned a suitability index value of 0.10, low has a value of 0.25, moderate has a value of 0.50, above average has a value of 0.75, and high has a value of 1.0.

Research to date suggests that ideal wetland and beaver pond habitats, which provide optimal salmonid production, possess the following features (Slaney and Zaldokas 1997):



Habitat Suitability and Water Temperature

FIGURE 3.2-8

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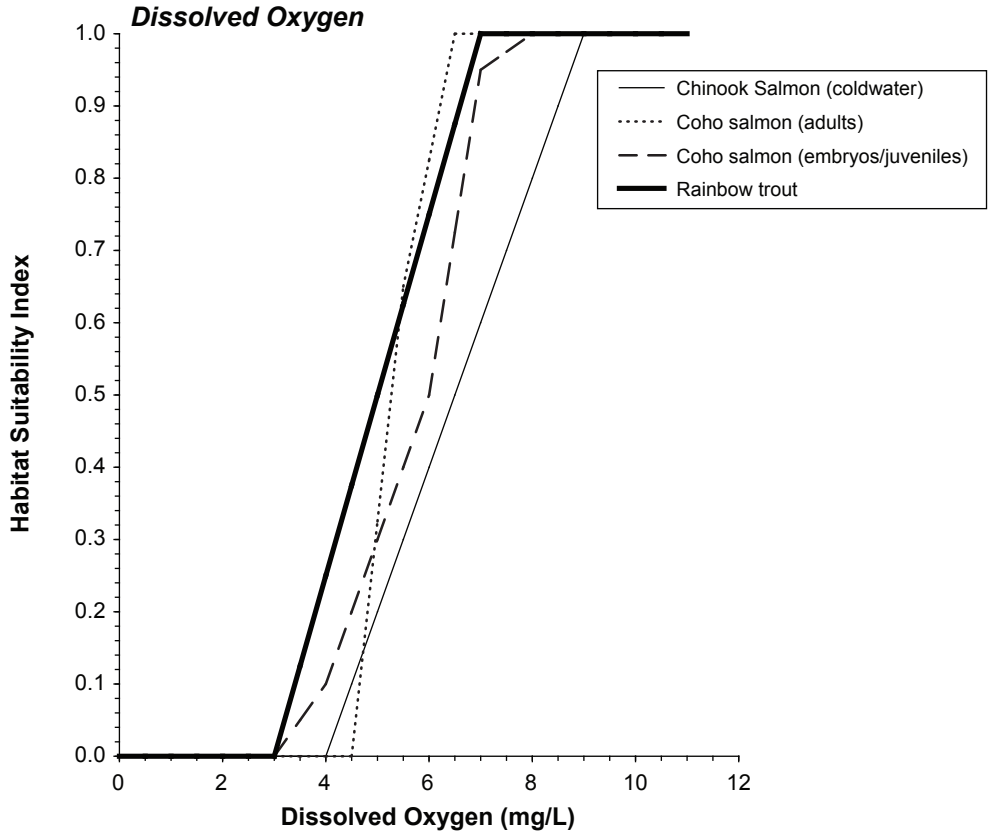

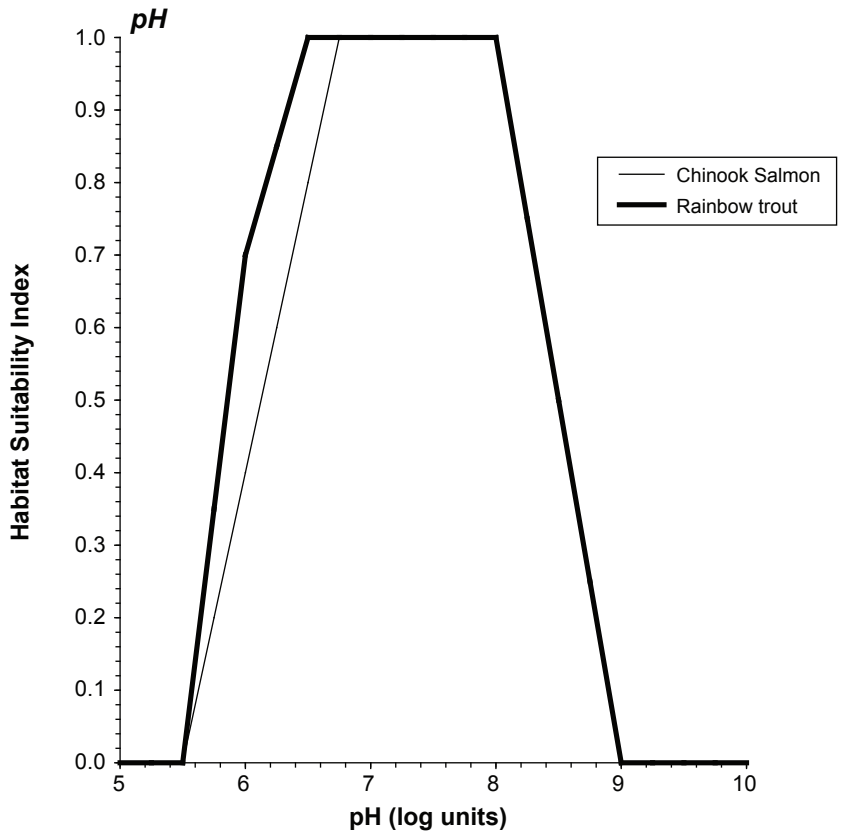

Habitat Suitability and Dissolved Oxygen and pH

FIGURE 3.2-9

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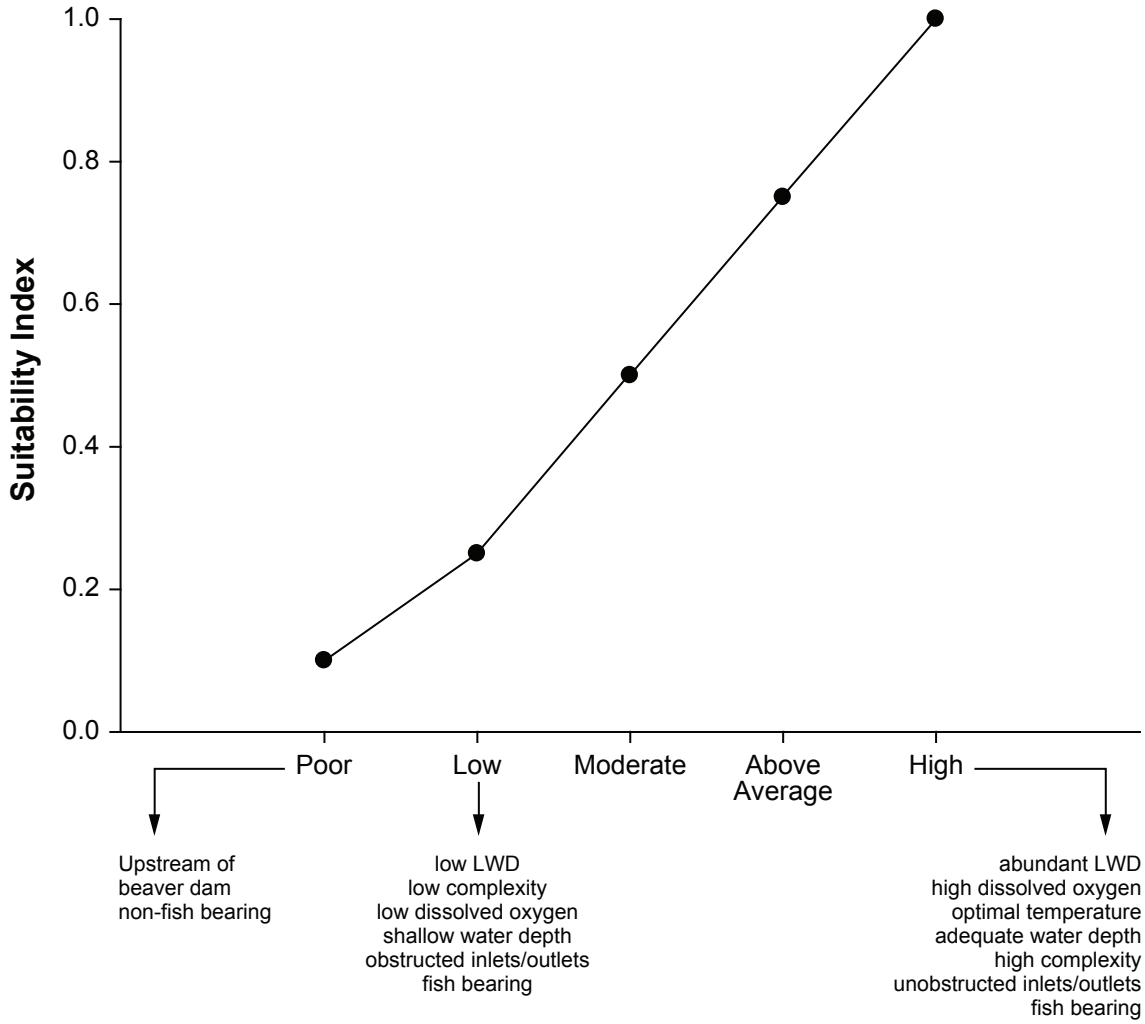

Generalized Habitat Suitability Curve for Wetland Species

FIGURE 3.2-10

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- small individual wetland/pond complexes;
- diverse water depths for fish growth and overwinter security;
- sufficient water depth for overwintering survival;
- suitable water temperatures and dissolved oxygen levels;
- defined inlet and outlet channels for water exchange and to allow for fish passage; and
- abundant LWD cover for improved rearing and overwintering capability.

In narrative terms, poor quality habitat is characterized by absent/restricted inlet and outlet channels, shallow water depth, low LWD cover, water temperatures and pH outside the optimal range, and low concentrations of dissolved oxygen. High quality habitat is characterized by defined and unobstructed inlet and outlet channels, sufficient water depth, high LWD cover complexity, water temperatures and pH within the optimal range, and high concentrations of dissolved oxygen.

Comparison of stream HSI models for coho salmon and Dolly Varden showed that each model has four life history stages. Each of these stages broadly relate to spawning, migration, rearing, and overwintering habitat. These life history stages were simplified for wetlands because of the lack of peer reviewed wetland HSI models. Since there is no spawning or embryo development or migration stages for Dolly Varden and coho salmon in wetland/pond habitats, these life stages were not included.

Wetland habitat suitability for each life stage was assessed based upon characteristics that provide optimal salmonid production (see above), professional experience, site-specific habitat data, and site-specific biological fisheries data.

4. Project Habitat Impact Assessment

4.1 HABITAT LOSS DETERMINATION

The Plan is concerned exclusively with the destruction of fish habitat within the footprint of the proposed TMF/seepage collection ponds. The MMER (SOR/2002-222), under Section 36 of the *Fisheries Act* (1985), regulates the deposit of mine tailing and other waste matter produced during mining operations into natural fish-bearing waters. Therefore, the presence of natural fish-bearing waters within South Teigen and North Treaty creeks, under the proposed TMF, triggers Section 36 of the *Fisheries Act*.

4.2 HABITAT LOSS IDENTIFICATION

For the purposes of describing fish habitat, watercourses impacted by the TMF are presented in tabular format by watershed and watercourse type (i.e., mainstem, tributary, and wetland). Sensitive Habitat Inventory Mapping (SHIM) was used to characterize fish habitat within the TMF in 2009 (Rescan 2010). Mainstem and tributary tables present channel characteristics such as bankfull width (m), bankfull depth (m), residual pool depth (m), etc. Mainstem and tributary tables present size, instream, riparian, and habitat quality characteristics such as area (m^2), habitat unit ratio (%), habitat weighted cover composition (% by unit area), riparian vegetation type (% by stream length), rearing habitat quality (% of stream length), etc. Wetland tables present size, instream, riparian, and habitat quality characteristics such as area (m^2), bed composition (%), instream cover presence, etc. Detailed descriptions of affected watercourses, from a watershed perspective, were previously provided in Section 2.2. Locations of these watercourses are shown in Figures 2.2-1 to 2.2-5. Photographs of the watercourses are provided in Appendix 4.2-1.

Mapped watercourses were sampled to confirm fish presence (Rescan 2009, 2010). Fisheries field crews commenced electrofishing at the tributary confluence, with South Teigen or North Treaty creek mainstems, and proceeded upstream to determine the point of "end of fish use."

Wetlands were sampled; however, no fish were caught in Wetland NT-W2 despite 125 hours of minnow trap effort in 2009 and 52 hours of minnow trap and 850 seconds of electrofishing effort in 2008 (Rescan 2009, 2010). The presence of a beaver dam likely restricts upstream fish movement into this wetland and other watercourses upstream of it. However, this wetland and other watercourses upstream of it are considered fish habitat because beaver dams are temporary barriers to fish movement.

Four mainstem reaches in South Teigen Creek will be affected by the construction and operation of the TMF and seepage collection ponds, which represent a total fish habitat area of 41,827 m^2 (Tables 4.2-1 and 4.2-2). Nineteen tributaries will be affected in South Teigen Creek, representing a total fish habitat area of 12,093 m^2 (Tables 4.2-3 and 4.2-4). The two wetlands affected in South Teigen Creek, represent a total fish habitat area of 1,853 m^2 (Tables 4.2-5 and 4.2-6).

Two mainstem reaches will be affected in North Treaty Creek, which represent a total fish habitat area of 16,265 m^2 (Tables 4.2-7 and 4.2-8). There are 27 tributaries affected in North Treaty Creek, which represent a total fish habitat area of 8,163 m^2 (Tables 4.2-9 and 4.2-10). There are three wetlands affected in North Treaty Creek, which represent a total fish habitat area of 9,389 m^2 (Tables 4.2-5 and 4.2-6).

Table 4.2-1. South Teigen Mainstem: Channel Characteristics

Attribute	Reach				
	4 (Seepage Pond)	4 (TMF)	5 (TMF)	6 (TMF)	8 (TMF)
Bankfull Width (m)					
Mean	11.33	7.67	6.44	5.06	8.00
SE	0.67	0.46	0.77	0.27	-
Wetted Width (m)					
Mean	10.67	6.28	6.14	4.61	7.80
SE	0.83	0.40	0.75	0.08	-
Bankfull Depth (m)					
Mean	0.99	0.97	0.84	0.55	0.70
SE	0.25	0.16	0.14	0.13	-
Wetted Depth (m)					
Mean	0.55	0.56	0.51	0.28	0.50
SE	0.21	0.11	0.09	0.02	-
Residual Pool Depth (m)					
Mean	-	0.97	0.93	-	-
SE	-	0.44	0.18	-	-
Gradient (%)					
Mean	3.50	2.75	1.00	5.00	6.00
SE	0.33	0.55	-	-	1.00

Dashes indicate not present or not applicable

SE = standard error of the mean

Table 4.2-2. Affected South Teigen Mainstem: Instream, Riparian, and Habitat Quality Characteristics

Attribute	Descriptor	Reach				
		4 (Seep Pond)	4 (TMF)	5 (TMF)	6 (TMF)	8 (TMF)
Stream Length Mapped	m	406.0	1420.0	1534.0	770.0	608.0
Mean Channel Width	m	11.33	7.67	6.44	5.06	8.00
Stream Area Mapped	m^2	12,304.4	10,891.0	9,871.3	3,896.0	4,864.0
Habitat Unit Ratio (%)	Riffle	34.0	60.0	35.0	90.0	0.0
	Cascade	44.0	13.0	0.0	10.0	100.0
	Pool	22.0	21.0	25.0	0.0	0.0
	Glide	0.0	6.0	40.0	0.0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	0.0	7.9	25.3	52.1	0.0
	Gravel	16.5	35.2	63.5	47.9	0.0
	Cobble	77.1	52.2	7.8	0.0	80.0
	Boulder	6.5	4.7	3.4	0.0	20.0
	Bedrock	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	28.2	10.3	19.4	0.0	10.0
	Boulder	6.5	2.5	1.3	0.0	20.0
	Instream Vegetation	0.0	0.0	0.0	0.0	0.0
	Overhanging Vegetation	3.2	6.4	5.0	12.1	0.0
	Undercut Bank	0.0	3.3	6.0	5.0	0.0
	Large Woody Debris	3.5	0.0	0.0	0.0	0.0
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	100.0	100.0	0.0
	Shrubs	41.1	23.3	0.0	0.0	0.0
	Coniferous Forest	58.9	76.7	0.0	0.0	0.0
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	0.0	100.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0
	Tall Shrub (2-10m)	41.1	23.3	100.0	100.0	0.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0
	Young Forest	28.8	60.9	0.0	0.0	0.0
	Mature Forest	30.1	15.7	0.0	0.0	100.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	40.4	5.4	100.0	100.0	0.0
	1-20%	59.6	94.6	0.0	0.0	85.4
	21-40%	0.0	0.0	0.0	0.0	14.6
	41-70%	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	100.0	85.3	0.0	100.0	100.0
	Large Channel	0.0	0.0	0.0	0.0	0.0
	Riffle Pool	0.0	14.7	100.0	0.0	0.0
	Step Pool	0.0	0.0	0.0	0.0	0.0
Bank Stability - % by stream length	Stable - Undercut	0.0	25.2	100.0	100.0	0.0
	Stable - No Undercut	100.0	74.8	0.0	0.0	0.0
	Aggrading	0.0	0.0	0.0	0.0	14.6
	Eroding	0.0	0.0	0.0	0.0	85.4
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0	0.0
	Fines	0.0	15.7	100.0	100.0	100.0
	Gravel	0.0	0.0	0.0	0.0	0.0
	Cobble	95.1	79.1	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0
	Bedrock	4.9	5.1	0.0	0.0	0.0

(continued)

Table 4.2-2. Affected South Teigen Mainstem: Instream, Riparian, and Habitat Quality Characteristics (completed)

Attribute	Descriptor	Reach				
		4 (Seep Pond)	4 (TMF)	5 (TMF)	6 (TMF)	8 (TMF)
Spawning Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0
	Good	0.0	0.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	100.0	100.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0
	Good	100.0	100.0	100.0	100.0	100.0
	None	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	0.0	0.0	0.0
OverWintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0
	Good	100.0	100.0	100.0	100.0	100.0
	None	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	0.0	0.0	0.0
Potential Spawning Habitat - % of stream length	Abundant	0.0	0.0	0.0	0.0	0.0
	Micropatches	0.0	0.0	0.0	0.0	0.0
	Moderate	0.0	0.0	0.0	0.0	0.0
	None	100.0	100.0	100.0	100.0	100.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0
	Important	100.0	100.0	100.0	100.0	100.0
	Marginal	0.0	0.0	0.0	0.0	0.0

Table 4.2-3. Affected South Teigen Watershed Tributaries: Channel Characteristics

Attribute	1005	1006	1007	1008	1009	1010	1011	1012	1019	1021	1022	1023	1025	1026	1028	1029	1030	1150	1206
Bankfull Width (m)																			
Mean	1.67	1.17	2.26	1.32	0.50	6.20	1.93	3.60	2.75	1.25	1.52	1.83	1.64	1.75	3.10	3.00	2.61	1.29	1.52
SE	0.09	0.08	0.31	0.08	-	0.25	0.30	0.06	0.25	0.09	0.26	0.24	-	0.13	0.10	0.00	0.45	0.05	-
Wetted Width (m)																			
Mean	1.64	1.00	1.26	0.98	0.46	6.21	1.90	3.40	3.75	1.23	1.43	1.88	1.40	1.88	3.20	3.00	3.04	1.42	1.39
SE	0.24	0.13	0.40	0.12	-	0.17	0.32	0.15	0.63	-	0.03	0.27	0.07	0.03	-	-	0.36	0.04	-
Bankfull Depth (m)																			
Mean	0.24	0.20	0.18	0.29	0.24	0.52	0.48	0.35	0.45	-	0.13	0.22	0.47	0.21	0.20	0.40	0.52	0.31	0.30
SE	0.05	0.02	0.03	0.01	-	0.06	0.14	0.08	0.16	-	0.03	0.06	0.17	0.04	-	-	0.14	0.05	-
Wetted Depth (m)																			
Mean	0.16	0.15	0.11	0.11	0.05	0.37	0.40	0.26	0.30	0.13	0.09	0.17	0.34	0.16	0.14	0.29	0.35	0.21	0.06
SE	0.02	0.04	0.01	0.02	0.00	0.06	0.04	0.05	0.06	0.03	0.00	0.01	0.17	0.01	0.00	0.02	0.04	0.01	0.01
Residual Pool Depth (m)																			
Mean	0.12	0.12	0.16	0.05	-	-	0.37	0.28	0.19	0.18	0.12	0.18	0.14	-	0.33	0.16	-	-	-
SE	0.01	0.01	0.07	0.01	-	-	0.07	0.07	0.05	0.04	0.02	0.05	0.02	-	0.07	0.07	-	-	-

Dashes indicate not present or not applicable

Table 4.2-4. Affected South Teigen Watershed Tributaries: Instream, Riparian, and Habitat Quality Characteristics

Attribute	Descriptor	1005	1006	1007	1008	1009	1010	1011	1012	1019	1021	1022	1023	1025	1026	1028	1029	1030	1150	1206
Stream Length Mapped	m	105.0	161.0	169.0	176.0	39.0	371.0	182.0	159.0	550.0	168.0	289.0	173.0	352.0	100.0	105.0	198.0	1143.0	525.0	39.0
Mean Channel Width	m	1.67	1.17	2.26	1.32	0.50	6.20	1.93	3.60	2.75	1.25	1.52	1.83	1.64	1.75	3.10	3.00	2.61	1.29	1.52
Stream Area Mapped	m^2	174.8	188.0	382.5	231.4	19.5	2,300.2	350.4	572.4	1,512.5	209.6	439.3	317.3	578.3	175.0	325.5	594.0	2,985.8	677.2	59.3
Habitat Unit Ratio (%)	Riffle	40.0	37.5	30.0	25.0	100.0	10.0	50.0	10.0	75.0	100.0	0.0	40.0	45.0	60.0	100.0	100.0	81.7	41.7	100.0
	Cascade	50.0	55.0	70.0	70.0	0.0	53.3	30.0	60.0	15.0	0.0	90.0	52.5	50.0	40.0	0.0	0.0	0.0	30.0	0.0
	Pool	10.0	7.5	0.0	5.0	0.0	36.7	20.0	30.0	10.0	0.0	10.0	7.5	5.0	0.0	0.0	0.0	1.7	5.0	0.0
	Glide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	23.3	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	43.7	15.9	5.5	9.4	20.0	1.3	0.0	4.0	12.8	0.0	2.0	5.7	1.4	0.0	50.0	60.0	12.9	37.7	40.0
	Gravel	43.0	52.1	94.5	82.9	80.0	38.9	96.2	57.1	87.2	100.0	32.0	58.4	98.6	68.9	50.0	40.0	72.9	37.2	60.0
	Cobble	13.3	32.0	0.0	7.7	0.0	54.8	3.8	26.9	0.0	0.0	65.9	35.9	0.0	31.1	0.0	0.0	14.2	22.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	5.0	0.0	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	8.4	13.2	2.8	11.3	0.0	34.6	19.8	27.6	12.8	0.0	16.1	3.1	0.0	0.0	0.0	0.0	1.3	3.3	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	4.2	0.0	11.9	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	3.1	0.0
	Instream Vegetation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	80.0
	Overhanging Vegetation	4.6	0.0	37.6	4.7	80.0	2.7	4.5	0.5	42.3	90.0	18.0	18.6	2.4	2.0	100.0	100.0	27.0	48.8	0.0
	Undercut Bank	0.0	2.1	0.0	0.0	20.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
	Large Woody Debris	10.6	2.8	0.0	5.9	0.0	9.1	15.0	14.0	10.1	0.0	20.5	14.0	10.0	14.1	0.0	0.0	0.0	6.8	0.0
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	13.1	0.0	20.2	7.4	83.0	75.2	100.0	68.3	14.1	100.0
	Shrubs	0.0	0.0	16.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Coniferous Forest	100.0	100.0	84.0	100.0	0.0	100.0	100.0	100.0	81.8	86.9	100.0	79.8	92.6	17.0	24.8	0.0	0.0	85.9	0.0
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.7	0.0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tall Shrub (2-10m)	0.0	0.0	16.0	0.0	100.0	0.0	0.0	0.0	18.2	13.1	0.0	20.2	7.4	83.0	75.2	100.0	68.3	14.1	100.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	72.7	0.0
	Mature Forest	0.0	0.0	84.0	100.0	0.0	100.0	100.0	100.0	81.8	86.9	100.0	79.8	92.6	17.0	24.8	0.0	17.7	13.2	0.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	18.2	39.3	0.0	100.0	7.4	83.0	75.2	100.0	82.3	14.1	0.0
	1-20%	100.0	0.0	16.0	100.0	0.0	100.0	67.0	100.0	81.8	60.7	0.0	0.0	92.6	17.0	24.8	0.0	17.7	85.9	100.0
	21-40%	0.0	100.0	84.0	0.0	0.0	0.0	33.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	0.0	60.2	16.0	0.0	0.0	62.0	74.2	39.8	29.3	0.0	0.0	0.0	21.6	17.0	0.0	0.0	17.7	36.3	0.0
	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Riffle Pool	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	18.2	39.3	0.0	20.2	7.4	83.0	100.0	100.0	82.3	63.7	100.0
	Step Pool	0.0	39.8	84.0	100.0	0.0	38.0	25.8	60.2	52.5	60.7	100.0	79.8	71.0	0.0	0.0	0.0	0.0	0.0	0.0

(continued)

Table 4.2-4. Affected South Teigen Watershed Tributaries: Instream, Riparian, and Habitat Quality Characteristics (completed)

Attribute	Descriptor	1005	1006	1007	1008	1009	1010	1011	1012	1019	1021	1022	1023	1025	1026	1028	1029	1030	1150	1206
Bank Stability - % by stream length	Stable - Undercut	0.0	60.2	0.0	0.0	0.0	0.0	0.0	100.0	13.6	0.0	0.0	0.0	52.8	0.0	0.0	0.0	53.4	14.1	100.0
	Stable - No Undercut	100.0	39.8	100.0	100.0	100.0	100.0	33.0	0.0	68.2	100.0	100.0	100.0	39.8	17.0	100.0	100.0	28.9	85.9	0.0
	Aggrading	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	0.0	0.0	0.0	7.4	83.0	0.0	0.0	0.0	0.0	0.0
	Eroding	0.0	0.0	0.0	0.0	0.0	0.0	67.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.7	0.0	0.0
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fines	100.0	100.0	16.0	100.0	100.0	0.0	0.0	39.8	86.4	100.0	100.0	100.0	31.3	0.0	100.0	100.0	71.1	100.0	100.0
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0	74.2	0.0	0.0	0.0	0.0	0.0	29.0	83.0	0.0	0.0	28.9	0.0	0.0
	Cobble	0.0	0.0	84.0	0.0	0.0	100.0	25.8	0.0	13.6	0.0	0.0	0.0	39.8	17.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spawning Habitat Quality - % of stream length	Fair	8.6	47.2	0.0	0.0	61.5	0.0	0.0	0.0	18.2	63.1	49.5	20.2	0.0	0.0	75.2	100.0	0.0	23.1	0.0
	Good	91.4	13.0	16.0	0.0	0.0	100.0	33.0	92.8	68.2	13.1	0.0	0.0	60.2	0.0	24.8	0.0	14.9	49.6	0.0
	None	0.0	0.0	0.0	0.0	38.5	0.0	0.0	7.2	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	39.8	84.0	100.0	0.0	0.0	67.0	0.0	0.0	23.8	50.5	79.8	39.8	100.0	0.0	0.0	85.1	27.3	100.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	13.6	0.0	0.0	100.0	39.8	0.0	100.0	0.0	53.4	0.0	0.0
	Good	100.0	0.0	0.0	0.0	0.0	100.0	74.2	92.8	68.2	0.0	49.5	0.0	60.2	0.0	0.0	100.0	28.9	54.6	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	100.0	100.0	100.0	100.0	0.0	25.8	0.0	18.2	100.0	50.5	0.0	0.0	100.0	0.0	0.0	17.7	45.4	100.0
OverWintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.0	0.0	0.0	0.0	79.8	0.0	0.0	75.2	100.0	100.0	0.0	0.0
	Good	0.0	0.0	0.0	0.0	0.0	100.0	0.0	53.0	81.8	0.0	0.0	0.0	52.8	0.0	0.0	0.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	0.0	38.5	0.0	0.0	0.0	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Poor	100.0	100.0	100.0	100.0	61.5	0.0	100.0	0.0	0.0	100.0	100.0	20.2	47.2	100.0	24.8	0.0	0.0	100.0	0.0
Potential Spawning Habitat - % of stream length	Abundant	0.0	13.0	0.0	0.0	0.0	100.0	0.0	92.8	68.2	13.1	0.0	0.0	0.0	0.0	0.0	0.0	14.9	5.0	0.0
	Micropatches	100.0	0.0	100.0	100.0	0.0	0.0	67.0	0.0	13.6	60.7	100.0	100.0	39.8	0.0	0.0	0.0	0.0	72.7	0.0
	Moderate	0.0	87.0	0.0	0.0	61.5	0.0	33.0	0.0	0.0	26.2	0.0	0.0	60.2	100.0	24.8	0.0	67.4	22.3	100.0
	None	0.0	0.0	0.0	0.0	38.5	0.0	0.0	7.2	18.2	0.0	0.0	0.0	0.0	0.0	75.2	100.0	17.7	0.0	0.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Important	100.0	13.0	16.0	0.0	0.0	100.0	74.2	100.0	81.8	39.3	49.5	20.2	60.2	0.0	100.0	100.0	100.0	88.3	0.0
	Marginal	0.0	87.0	84.0	100.0	100.0	0.0	25.8	0.0	18.2	60.7	50.5	79.8	39.8	100.0	0.0	0.0	0.0	11.7	100.0

Table 4.2-5. Affected Summary of Wetland Characteristics within South Teigen and North Treaty Watersheds

Watershed	Wetland Name	Pond No.	Open Water (%)	Max Water Depth (m)	Area (m^2)
North Treaty	NT-W3	3	100	0.7	624
	NT-W2	4	100	0.7	4,344
	NT-W1	2	100	1.5	4,421
South Teigen	ST-W1	5	-	0.8	1,544
	ST-W3	1	80	-	309

Dashes indicate no data avaiable

Table 4.2-6. Summary of Wetland Habitat Affected within South Teigen and North Treaty Watersheds

			Bed Composition (%)					Instream Cover Presence								
Watershed	Wetland Name	Pond No.	Sand	Gravel	Cobble	Boulder	Bedrock	Pool	Boulder	IV	OV	UB	LWD	Riparian Vegetation	Fish Habitat (Y/N)	Fish Present (Y/N)	Comments
North Treaty	NT-W3	3	95	5	0	0	0	D	-	SD	SD	-	-	Tall Shrub	Y	N	Old beaver dam at outlet to larger beaver pond, no fish caught in pond.
	NT-W2	4	100	0	0	0	0	D	-	SD	SD	-	-	Tall Shrub	Y	N	Old beaver dam at outlet, fish present on other side of dam, no fish caught in pond.
	NT-W1	2	100	0	0	0	0	D	-	SD	T	-	-	Tall Shrub	Y	N	Old beaver dam at outlet to larger beaver pond, no fish caught in pond.
South Teigen	ST-W1	5	100	0	0	0	0	D	-	SD	T	-	-	Grass	Y	Y	Direct connection to mainstem South Teigen, DV caught in pond.
	ST-W3	1	100	0	0	0	0	D	-	SD	SD	-	T	Tall Shrub	Y	Y	Old beaver pond and dam, connected by channels to mainstem.

IV = instream vegetation

OV = overhanging vegetation

UB = undercut bank

LWD = large woody debris

D = dominant

SD = sub-dominant

T = trace

Dashes indicate not applicable

Table 4.2-7. North Treaty Mainstem: Channel Characteristics

Attribute	Reach	
	1 (Seepage Pond)	2 (TMF)
Bankfull Width (m)		
Mean	5.50	6.07
SE	0.50	0.53
Wetted Width (m)		
Mean	5.50	5.69
SE	0.50	0.36
Bankfull Depth (m)		
Mean	0.40	0.65
SE	-	0.12
Wetted Depth (m)		
Mean	-	0.42
SE	-	0.08
(m)		
Mean	0.50	0.45
SE	-	0.15
Gradient (%)		
Mean	5.8	2.0
SE	1.49	-

Dashes indicate not present or not applicable

Table 4.2-8. Affected North Treaty Mainstem: Instream, Riparian and Habitat Quality Characteristics

Attribute	Descriptor	Reach	
		1 (Seepage Pond)	2 (TMF)
Stream Length Mapped	m	690.0	1633.0
Mean Channel Width	m	5.50	6.07
Stream Area Mapped	m^2	6,358.0	9,906.9
Habitat Unit Ratio (%)	Riffle	0.0	58.9
	Cascade	60.0	8.3
	Pool	40.0	32.8
	Glide	0.0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	7.7	13.8
	Gravel	55.5	68.6
	Cobble	27.7	16.0
	Boulder	9.1	1.6
	Bedrock	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	10.0	33.1
	Boulder	11.4	1.0
	Instream Vegetation	0.0	0.0
	Overhanging Vegetation	56.8	32.4
	Undercut Bank	0.0	0.0
	Large Woody Debris	10.0	8.9
Riparian Vegetation Type - % by stream length	None	0.0	0.0
	Natural Wetland	0.0	0.0
	Shrubs	30.8	44.5
	Coniferous Forest	69.2	55.5
	Deciduous Forest	0.0	0.0
	Mixed Forest	0.0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0
	Tall Shrub (2-10m)	30.8	44.5
	Sapling (>10m)	0.0	0.0
	Young Forest	0.0	0.0
	Mature Forest	69.2	55.5
	Old Growth Forest	0.0	0.0
Riparian Crown Closure - % by stream length	0	30.8	24.9
	1-20%	69.2	75.1
	21-40%	0.0	0.0
	41-70%	0.0	0.0
	71-90%	0.0	0.0
	>90%	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	13.8	0.0
	Large Channel	0.0	0.0
	Riffle Pool	30.8	100.0
	Step Pool	55.5	0.0
Bank Stability - % by stream length	Stable - Undercut	0.0	24.9
	Stable - No Undercut	100.0	75.1
	Aggrading	0.0	0.0
	Eroding	0.0	0.0
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0
	Fines	0.0	77.5
	Gravel	30.8	0.0
	Cobble	44.2	22.5
	Boulder	0.0	0.0
	Bedrock	25.0	0.0

(continued)

Table 4.2-8. Affected North Treaty Mainstem: Instream, Riparian and Habitat Quality Characteristics (completed)

Attribute	Descriptor	Reach	
		1 (Seepage Pond)	2 (TMF)
Spawning Habitat Quality - % of stream length	Fair	0.0	29.4
	Good	100.0	67.0
	None	0.0	0.0
	Poor	0.0	3.6
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0
	Good	100.0	100.0
	None	0.0	0.0
	Poor	0.0	0.0
OverWintering Habitat Quality - % of stream length	Fair	0.0	0.0
	Good	100.0	96.4
	None	0.0	0.0
	Poor	0.0	3.6
Potential Spawning Habitat - % of stream length	Abundant	75.0	68.5
	Micropatches	0.0	3.6
	Moderate	25.0	27.9
	None	0.0	0.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0
	Important	100.0	100.0
	Marginal	0.0	0.0

Table 4.2-9. North Treaty Watershed Tributaries: Channel Characteristics

Attribute		1051	1052	1053	1054	1055	1056	1057	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068
Bankfull Width (m)																		
	Mean	1.8	1.42	1.80	1.54	1.65	1.46	1.40	1.88	3.59	0.73	1.20	0.70	0.69	1.15	0.99	1.75	1.00
	SE	0.3	0.02	-	0.17	-	-	-	0.13	0.55	-	0.22	-	-	-	-	-	-
Wetted Width (m)																		
	Mean	1.76	1.42	1.80	1.37	1.65	1.46	0.40	1.85	3.30	0.73	1.42	0.70	0.69	1.15	0.99	1.70	1.00
	SE	0.27	0.02	-	-	-	-	-	0.45	-	-	0.02	-	-	-	-	-	-
Bankfull Depth (m)																		
	Mean	0.3	0.21	0.20	0.27	0.16	-	0.20	0.33	0.60	0.06	0.65	-	-	-	-	0.20	-
	SE	0.1	0.01	-	-	-	-	-	0.18	-	-	0.25	-	-	-	-	-	-
Wetted Depth (m)																		
	Mean	0.2	0.15	0.05	0.21	0.11	0.08	0.07	0.24	0.17	0.04	0.30	-	-	-	-	0.10	-
	SE	0.0	0.01	0.00	0.01	0.01	0.03	0.02	0.00	0.02	0.00	0.11	-	-	-	-	0.00	-
Residual Pool Depth (m)																		
	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20
	SE																	

Attribute		1069	1070	1071	1072	1081	1082	1083	1084	1085	1086	1087	1089	1101
Bankfull Width (m)														
	Mean	0.40	0.81	0.81	0.94	1.67	1.75	0.83	1.30	0.65	1.84	1.06	0.50	0.50
	SE	-	-	-	0.24	-	0.15	-	-	-	0.03	0.06	-	-
Wetted Width (m)														
	Mean	0.40	0.81	0.81	0.94	1.67	2.17	0.83	1.30	0.65	1.85	1.06	0.50	0.50
	SE	-	-	-	-	-	0.03	-	-	-	0.05	-	-	-
Bankfull Depth (m)														
	Mean	-	-	-	-	-	0.42	-	-	-	0.45	-	-	0.05
	SE	-	-	-	-	-	0.08	-	-	-	0.05	-	-	-
Wetted Depth (m)														
	Mean	-	-	-	-	-	0.22	-	-	-	0.27	-	-	0.03
	SE	-	-	-	-	-	0.03	-	-	-	0.05	-	-	0.01
Residual Pool Depth (m)														
	Mean	-	-	-	-	-	0.16	-	-	-	-	-	-	-
	SE													

Dashes indicate not present or not applicable

Table 4.2-10. Affected North Treaty Watershed Tributaries: Instream, Riparian Habitat, and Habitat Quality Characteristics

Attribute	Descriptor	1054	1055	1056	1057	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068
Stream Length Mapped	m	136.0	135.0	45.0	29.0	797.0	707.0	31.0	245.0	15.0	29.0	39.0	15.0	81.0	70.0
Mean Channel Width	m	1.54	1.65	1.46	1.40	1.88	3.59	0.73	1.20	0.70	0.69	1.15	0.99	1.75	1.00
Stream Area Mapped	m^2	209.4	222.8	65.7	40.6	1497.2	2535.1	22.6	293.2	10.5	20.0	44.9	14.9	141.8	70.0
Habitat Unit Ratio (%)	Riffle	100.0	100.0	0.0	100.0	100.0	0.0	100.0	60.0	100.0	100.0	0.0	0.0	100.0	100.0
	Cascade	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0
	Glide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	90.0	20.0	75.0	80.0	74.2	0.0	80.0	20.0	100.0	60.0	100.0	100.0	100.0	100.0
	Gravel	10.0	80.0	25.0	20.0	25.8	10.0	20.0	80.0	0.0	40.0	0.0	0.0	0.0	0.0
	Cobble	0.0	0.0	0.0	0.0	0.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.6	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Instream Vegetation	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Overhanging Vegetation	0.0	10.0	40.0	5.0	52.4	0.0	5.0	80.0	100.0	100.0	50.0	100.0	40.0	100.0
	Undercut Bank	0.0	0.0	0.0	0.0	1.8	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
	Large Woody Debris	10.0	10.0	10.0	0.0	1.8	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	21.3	0.0	0.0	0.0	5.3	27.7	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Shrubs	47.8	0.0	0.0	0.0	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Coniferous Forest	30.9	100.0	100.0	100.0	82.2	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	0.0	0.0	72.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tall Shrub (2-10m)	69.1	0.0	0.0	0.0	17.8	27.7	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	0.0	0.0	0.0	100.0	82.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mature Forest	30.9	100.0	100.0	0.0	0.0	72.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	0.0	0.0	0.0	0.0	12.4	27.7	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	1-20%	100.0	0.0	100.0	100.0	87.6	41.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-40%	0.0	100.0	0.0	0.0	0.0	31.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(continued)

Table 4.2-10. Affected North Treaty Watershed Tributaries: Instream, Riparian Habitat, and Habitat Quality Characteristics (continued)

Attribute	Descriptor	1069	1070	1071	1072	1081	1082	1083	1084	1085	1086	1087	1089	1101
Stream Length Mapped	m	12.0	36.0	16.0	337.0	64.0	1052.0	66.0	128.0	89.0	53.0	232.0	72.0	14.0
Mean Channel Width	m	0.40	0.81	0.81	0.94	1.67	1.75	0.83	1.30	0.65	1.84	1.06	0.50	0.50
Stream Area Mapped	m^2	4.8	29.2	13.0	315.1	106.9	1839.8	54.8	166.4	57.9	97.3	246.7	36.0	7.0
Habitat Unit Ratio (%)	Riffle	100.0	100.0	100.0	100.0	100.0	95.0	100.0	100.0	100.0	90.0	100.0	100.0	100.0
	Cascade	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pool	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0
	Glide	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	100.0	100.0	100.0	90.0	100.0	51.3	100.0	90.0	10.0	31.0	30.0	100.0	10.0
	Gravel	0.0	0.0	0.0	10.0	0.0	48.7	0.0	10.0	90.0	69.0	70.0	0.0	90.0
	Cobble	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Instream Vegetation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Overhanging Vegetation	100.0	10.0	10.0	10.0	100.0	71.7	100.0	100.0	50.0	10.0	100.0	0.0	10.0
	Undercut Bank	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	1.0	0.0	0.0	0.0
	Large Woody Debris	0.0	50.0	50.0	50.0	0.0	6.8	0.0	0.0	0.0	19.0	0.0	0.0	0.0
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	100.0	0.0	0.0	0.0	0.0	51.7	100.0	100.0	100.0	0.0	62.1	0.0	0.0
	Shrubs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.9	100.0	100.0
	Coniferous Forest	0.0	100.0	100.0	100.0	100.0	22.1	0.0	0.0	0.0	100.0	0.0	0.0	0.0
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	0.0	0.0	26.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tall Shrub (2-10m)	100.0	100.0	100.0	0.0	0.0	46.5	100.0	100.0	100.0	0.0	100.0	100.0	100.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	0.0	0.0	0.0	0.0	0.0	36.9	0.0	0.0	0.0	100.0	0.0	0.0	0.0
	Mature Forest	0.0	0.0	0.0	100.0	100.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	100.0	0.0	0.0	0.0	0.0	7.3	100.0	0.0	0.0	0.0	100.0	100.0	100.0
	1-20%	0.0	0.0	0.0	0.0	100.0	46.5	0.0	100.0	100.0	100.0	0.0	0.0	0.0
	21-40%	0.0	100.0	100.0	100.0	0.0	46.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(continued)

Table 4.2-10. Affected North Treaty Watershed Tributaries: Instream, Riparian Habitat, and Habitat Quality Characteristics (continued)

Attribute	Descriptor	1054	1055	1056	1057	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068
Channel Morphology	Cascade Pool	30.9	0.0	100.0	0.0	0.0	65.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % by stream length	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Riffle Pool	69.1	100.0	0.0	100.0	100.0	34.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Step Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bank Stability	Stable - Undercut	0.0	0.0	0.0	0.0	94.7	27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % by stream length	Stable - No Undercut	100.0	100.0	100.0	100.0	5.3	18.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Aggrading	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Eroding	0.0	0.0	0.0	0.0	0.0	53.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dominant Bank Substrate	Organics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % by stream length	Fines	100.0	100.0	100.0	100.0	100.0	46.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cobble	0.0	0.0	0.0	0.0	0.0	53.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spawning Habitat Quality	Fair	30.9	100.0	0.0	0.0	32.7	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % of stream length	Good	21.3	0.0	0.0	0.0	12.4	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	0.0	5.3	81.2	0.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0
	Poor	47.8	0.0	100.0	100.0	49.5	11.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rearing Habitat Quality	Fair	69.1	0.0	0.0	0.0	5.3	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % of stream length	Good	0.0	0.0	0.0	0.0	94.7	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	30.9	100.0	100.0	100.0	0.0	88.1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
OverWintering Habitat	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quality	Good	0.0	0.0	0.0	0.0	82.2	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
- % of stream length	None	0.0	0.0	0.0	0.0	0.0	27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	100.0	17.8	72.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Potential Spawning Habitat	Abundant	52.2	100.0	0.0	0.0	12.4	6.9	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0
- % of stream length	Micropatches	47.8	0.0	100.0	0.0	49.5	0.0	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
	Moderate	0.0	0.0	0.0	0.0	32.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	100.0	5.3	93.1	0.0	0.0	0.0	0.0	100.0	0.0	100.0	100.0
Overall Habitat Quality	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % of stream length	Important	21.3	0.0	0.0	0.0	94.7	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
	Marginal	78.7	100.0	100.0	100.0	5.3	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0

(continued)

Table 4.2-10. Affected North Treaty Watershed Tributaries: Instream, Riparian Habitat, and Habitat Quality Characteristics (completed)

Attribute	Descriptor	1069	1070	1071	1072	1081	1082	1083	1084	1085	1086	1087	1089	1101
Channel Morphology	Cascade Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.9	0.0	100.0
- % by stream length	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Riffle Pool	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	62.1	100.0	0.0
	Step Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bank Stability	Stable - Undercut	0.0	100.0	100.0	0.0	0.0	11.5	0.0	100.0	0.0	100.0	62.1	0.0	0.0
- % by stream length	Stable - No Undercut	100.0	0.0	0.0	100.0	100.0	88.5	100.0	0.0	100.0	0.0	37.9	100.0	100.0
	Aggrading	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Eroding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dominant Bank Substrate	Organics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % by stream length	Fines	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Cobble	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spawning Habitat Quality	Fair	0.0	0.0	0.0	0.0	0.0	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % of stream length	Good	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	23.3	0.0	0.0
	None	100.0	100.0	100.0	0.0	100.0	53.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	0.0	100.0	0.0	8.4	0.0	100.0	0.0	0.0	76.7	100.0	100.0
Rearing Habitat Quality	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.3	100.0	0.0
- % of stream length	Good	0.0	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Poor	100.0	100.0	100.0	0.0	0.0	0.0	100.0	100.0	100.0	0.0	76.7	0.0	0.0
OverWintering Habitat	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Quality	Good	0.0	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % of stream length	None	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Poor	100.0	0.0	0.0	100.0	100.0	88.5	100.0	100.0	100.0	0.0	100.0	100.0	0.0
Potential Spawning Habitat	Abundant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	23.3	0.0	0.0
- % of stream length	Micropatches	0.0	0.0	0.0	100.0	0.0	15.8	0.0	100.0	0.0	0.0	76.7	100.0	100.0
	Moderate	0.0	0.0	0.0	0.0	0.0	37.7	0.0	0.0	0.0	100.0	0.0	0.0	0.0
	None	100.0	100.0	100.0	0.0	100.0	46.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Overall Habitat Quality	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- % of stream length	Important	0.0	0.0	0.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Marginal	100.0	100.0	100.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

4.3 HABITAT LOSS SUMMARY

Data required for calculating habitat budgets on the basis of the HSI models used the SHIM data (Rescan 2010). These HSI models incorporated instream and riparian habitat values to develop the habitat budgets. HSI values for affected watercourse were determined for each Dolly Varden habitat variable and life history stage (Appendix 4.3-1). HUs for affected watercourses were calculated for each life history stage. A summary of total area and HU lost is summarized in Tables 4.3-1 and 4.3-2. Figures 2.2-1 to 2.2-5 show the location of streams and wetlands to be lost.

A total area of 89,620 m^2 (8.96 ha) of fish habitat (7.83 ha from streams and 1.12 ha from wetlands) will be lost from South Teigen and North Treaty watersheds due to the deposit of deleterious substances into the proposed TMF and seepage collection ponds. This represents a total of 153,982 HUs (148,823 HU from streams and 5,120 ha from wetlands).

Table 4.3-1. Dolly Varden Stream Habitat Loss Summary

Watershed	Habitat Type	Waterbody Name	Area Loss (m^2)	Dolly Varden Habitat Loss								Total HU Loss
				Adult		Embryonic Stage		Fry Rearing		Parr Rearing		
				HS	HU	HS	HU	HS	HU	HS	HU	
South Teigen	Stream	1005	174.8	0.25	44	0.1	17	0.25	44	0.25	44	149
South Teigen	Stream	1006	188.0	0.1	19	0.5	94	0.1	19	0.1	19	150
South Teigen	Stream	1007 A	61.1	0.1	6	1	61	0.1	6	0.1	6	79
South Teigen	Stream	1007 B	321.4	0.1	32	1	321	0.1	32	0.1	32	418
South Teigen	Stream	1008	231.4	0.1	23	1	231	0.1	23	0.1	23	301
South Teigen	Stream	1009	19.5	0.1	2	0.5	10	0.1	2	0.1	2	16
South Teigen	Stream	1010	2,300.2	0.5	1150	1	2300	0.5	1150	0.5	1150	5,751
South Teigen	Stream	1011 A	259.9	0.5	130	1	260	0.5	130	0.5	130	650
South Teigen	Stream	1011 B	90.5	0.1	9	1	90	0.1	9	0.1	9	118
South Teigen	Stream	1012	572.4	0.5	286	1	572	0.5	286	0.5	286	1,431
South Teigen	Stream	1019 A	1,237.5	0.1	124	1	1238	0.1	124	0.1	124	1,609
South Teigen	Stream	1019 B	275.0	0.1	28	1	275	0.1	28	0.1	28	358
South Teigen	Stream	1021	209.6	0.1	21	1	210	0.1	21	0.1	21	272
South Teigen	Stream	1022	439.3	0.1	44	1	439	0.1	44	0.1	44	571
South Teigen	Stream	1023 A	253.1	0.1	25	1	253	0.1	25	0.1	25	329
South Teigen	Stream	1023 B	64.2	0.25	16	1	64	0.25	16	0.25	16	112
South Teigen	Stream	1025	578.3	0.1	58	1	578	0.1	58	0.1	58	752
South Teigen	Stream	1026	175.0	0.1	18	1	175	0.1	18	0.1	18	228
South Teigen	Stream	1028	325.5	0.1	33	0.1	33	0.1	33	0.1	33	130
South Teigen	Stream	1029	594.0	0.1	59	0.1	59	0.1	59	0.1	59	238
South Teigen	Stream	1030	2,985.8	0.1	299	1	2986	0.1	299	0.1	299	3,882
South Teigen	Stream	1150	677.0	0.5	339	0.1	68	0.5	339	0.5	339	1,083
South Teigen	Stream	1206	59.3	0.1	6	0.1	6	0.1	6	0.1	6	24
South Teigen	Stream	1207	30.0	0.1	3	1	30	0.1	3	0.1	3	39
North Treaty	Stream	1054	209.4	0.1	21	0.1	21	0.1	21	0.1	21	84
North Treaty	Stream	1055	222.8	0.1	22	0.5	111	0.1	22	0.1	22	178
North Treaty	Stream	1056	65.7	0.1	7	0.1	7	0.1	7	0.1	7	26
North Treaty	Stream	1057	40.6	0.1	4	0.1	4	0.1	4	0.1	4	16
North Treaty	Stream	1059	1497.2	0.1	150	0.1	150	0.1	150	0.1	150	599
North Treaty	Stream	1060	2,535.1	0.1	254	1	2535	0.1	254	0.1	254	3,296
North Treaty	Stream	1061	22.6	0.1	2	0.1	2	0.1	2	0.1	2	9
North Treaty	Stream	1062	293.2	1	293	0.5	147	0.25	73	0.25	73	586
North Treaty	Stream	1063	10.5	0.1	1	0.1	1	0.1	1	0.1	1	4
North Treaty	Stream	1064	20.0	0.1	2	0.1	2	0.1	2	0.1	2	8

(continued)

Table 4.3-1. Dolly Varden Stream Habitat Loss Summary (completed)

Watershed	Habitat Type	Waterbody Name	Area Loss (m^2)	Dolly Varden Habitat Loss								Total HU Loss
				Adult		Embryonic Stage		Fry Rearing		Parr Rearing		
				HS	HU	HS	HU	HS	HU	HS	HU	
North Treaty	Stream	1065	44.9	0.1	4	0.1	4	0.1	4	0.1	4	18
North Treaty	Stream	1066	14.9	0.1	1	0.1	1	0.1	1	0.1	1	6
North Treaty	Stream	1067	141.8	0.1	14	0.1	14	0.1	14	0.1	14	57
North Treaty	Stream	1068	70.0	0.1	7	0.1	7	0.1	7	0.1	7	28
North Treaty	Stream	1069	4.8	0.1	0	0.1	0	0.1	0	0.1	0	2
North Treaty	Stream	1070	29.2	0.1	3	0.1	3	0.1	3	0.1	3	12
North Treaty	Stream	1071	13.0	0.1	1	0.1	1	0.1	1	0.1	1	5
North Treaty	Stream	1072	315.1	0.1	32	0.1	32	0.1	32	0.1	32	126
North Treaty	Stream	1081	106.9	0.1	11	0.1	11	0.1	11	0.1	11	43
North Treaty	Stream	1082	1,839.8	0.1	184	0.1	184	0.1	184	0.1	184	736
North Treaty	Stream	1083	54.8	0.1	5	0.1	5	0.1	5	0.1	5	22
North Treaty	Stream	1084	166.4	0.1	17	0.1	17	0.1	17	0.1	17	67
North Treaty	Stream	1085	57.9	0.1	6	1	58	0.1	6	0.1	6	75
North Treaty	Stream	1086	97.3	0.5	49	1	97	0.5	49	0.5	49	243
North Treaty	Stream	1087	246.7	0.1	25	0.1	25	0.1	25	0.1	25	99
North Treaty	Stream	1089	36.0	0.1	4	0.1	4	0.1	4	0.1	4	14
North Treaty	Stream	1101	7.0	0.1	1	1	7	0.1	1	0.1	1	9
South Teigen	Stream	South Teigen - Reach 8	4,864.0	0.1	486	1	4864	0.1	486	0.1	486	6,323
South Teigen	Stream	South Teigen - Reach 6	3,896.0	0.1	390	0.1	390	0.1	390	0.1	390	1,558
South Teigen	Stream	South Teigen - Reach 5	9,871.3	0.5	4936	0.25	2468	0.5	4936	0.5	4936	17,275
South Teigen	Stream	South Teigen - Reach 4	10,891.0	0.5	5446	1	10891	0.5	5446	0.5	5446	27,228
South Teigen	Stream	South Teigen - Reach 4 (seepage pond)	4,600.0	0.5	2300	1	4600	0.5	2300	0.5	2300	11,500
North Treaty	Stream	North Treaty - Reach 1	3,795.0	0.5	1898	1	3795	0.5	1898	0.5	1898	9,488
North Treaty	Stream	North Treaty - Reach 2 (seepage pond)	9,906.9	0.5	4953	1	9907	0.5	4953	0.5	4953	24,767
		Total	**68,110.3**									**123,194**

NA = not applicable

Table 4.3-2. Dolly Varden Wetland Habitat Loss Summary

Watershed	Habitat Type	Waterbody Name	Area Loss (m^2)	Dolly Varden Habitat Loss								Total HU Loss
				Migration		Spawning		Rearing		Overwintering		
				HS	HU	HS	HU	HS	HU	HS	HU	
South Teigen	Wetland	STW1	1,544.0	NA	NA	NA	NA	1	1544	1	1544	3,088
South Teigen	Wetland	STW3	309.0	NA	NA	NA	NA	0.25	77.25	0.25	77.25	155
North Treaty	Wetland	NTW1	4,421.0	NA	NA	NA	NA	0.1	442	0.1	442	884
North Treaty	Wetland	NTW2	4,344.0	NA	NA	NA	NA	0.1	434	0.1	434	869
North Treaty	Wetland	NTW3	624.0	NA	NA	NA	NA	0.1	62	0.1	62	125
		Total	**11,242.0**									**5,120**

NA = not applicable

5. Compensation Planning and Assessment

5.1 DESKTOP ANALYSIS

Fish habitat compensation planning is an iterative process. Compensation planning requires knowledge of project-related fish habitat impacts, fish presence and distribution within the study area, quality of habitat impacted, population size, and demography of affected species.

A desktop analysis was conducted prior to commencing fieldwork for compensation project identification and assessment. A background literature review was completed for watersheds within and outside of the fisheries study area boundaries. In addition, a background literature review was completed for species-specific habitat limiting factors based upon peer-reviewed papers. The watershed literature reviews focused identification of factors limiting productive capacity within individual watersheds. For example, identification of species and life history stages present, identification of known key habitats (e.g., overwintering and spawning areas), and identification of anthropogenic impacts within watersheds.

An extensive list of background literature pertaining to the fisheries study area is referenced in *Kerr-Sulphurets-Mitchell Project: 2009 Fisheries Baseline Study Report* (Rescan 2010), *Kerr-Sulphurets-Mitchell Project: 2008 Fisheries Baseline Study Report* (Rescan 2009), and *KSM Project: Environmental Assessment-Chapter 15* (Rescan 2012d). However, the following additional background literature was considered relevant: Tripp (1988), Applied Ecosystem Management (2000), SKR (1998),BC MOE (1988), FINS Consulting Ltd. (FINS; 2004), and Beak (1979).

A list of conceptual compensation techniques was developed based upon professional experience, literature reviews, project information, fish life history requirements, and design complexity (Slaney and Zaldokas 1997). For each concept technique, target species and life history stage, target habitat, primary and secondary objectives, and physical construction technique were identified (Table 5.1-1). Although Dolly Varden is the primary species impacted by the Project, salmon habitat compensation projects were preferred due to consultation with Aboriginal groups at KSM Project Fisheries Working Group meetings. In addition, Dolly Varden and salmon species overlap in habitat preferences. Target species include: bull trout, chinook salmon, coho salmon, sockeye salmon, and rainbow trout/steelhead. Descriptions of each compensation concept are discussed in further detail in Section 6.1.

Multiple watersheds within and surrounding the fish and aquatic habitat study area were examined for potential fish habitat compensation sites. These watersheds included: Treaty, Teigen, Hodkin, West Teigen, South Teigen, Gilbert, Todedada, Snowbank, Unuk, Bowser, Oweegee, Taft, Glacier, Mere, Skowill, Ritchie, Hodder, Spruce, and Bell-Irving. Preliminary compensation sites were identified through map review and assessment of terrain features. These sites were identified by keeping in mind DFO's *No Net Loss* principle through their hierarchy of habitat compensation preferences (DFO 1998). Certain compensation sites were also identified through a review of Highway 37 stream crossing assessment reports (FINS 2004) and online fisheries databases (e.g., BC MOE HabitatWizard; 2011).

The four most important criteria for compensation site identification were:

- moderate or high potential to provide adequate water supply (i.e., higher order streams versus first or second order streams);
- terrain slope less than 5%, especially along floodplains;

- proximity to known fish distribution and habitat quality (i.e., prioritization of areas in lower reaches along mainstems or floodplains versus headwaters with less fisheries resources or lower species composition); and
- biological benefit to target fish species.

Through this desktop analysis, a number of preliminary compensation sites were identified.

5.2 FIELD ASSESSMENT

5.2.1 Site Identification

Aerial reconnaissance and ground-truthing of the preliminary compensation sites occurred in 2009, 2010, and 2011. Sites were ground-truthed on multiple occasions to refine site objectives and identify opportunities, site-specific constraints, biological relevance, stability, permanence, target species, target habitat, and target life history stage. Assessment of site-specific constraints and opportunities included: water supply magnitude and dependability, flood risk, water quality, sediment supply, gradient, soil stability, site constructability and access, construction costs, stability and durability of instream structures, obstructions and beaver dam risk, and time to full functionality of site.

A qualitative feasibility assessment, based upon professional experience, was conducted in 2009, 2010, and 2011 for each preliminary compensation site. This assessment was conducted by a water resources engineer to determine the technical feasibility of the sites. Through an iterative process of elimination and refinement, a list of preliminary compensation sites was identified (Section 6.2). Potentially degraded sites were sought within and surrounding the fish and aquatic habitat study area; however, no sites were identified through field observations or engagement with Aboriginal groups.

Fish and fish habitat were assessed at each preliminary compensation site. Assessment methods are detailed in *KSM Project: 2010 Fisheries Baseline Study Report* (2011a) and *KSM Project: 2011 Fish and Fish Habitat Compensation Baseline Report* (2012a). A high level summary of fish and fish habitat assessment methods is provided below for the Plan.

5.2.2 Fish Habitat

Stream habitat was assessed by one or more methods, depending upon the site-specific objectives. Stream habitat assessment methods included: reconnaissance level habitat assessment, detailed fish habitat assessment procedures (FHAP), SHIM, overwintering habitat assessment, and spawning surveys.

Streams were assessed using methods based on the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Protocol* (RISC 2001) and the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Site Card Field Guide* (RISC 1999a). This protocol involved characterizing fish habitat by measuring physical attributes (channel width, gradient, temperature, water quality, etc.), characterizing cover types and substrate (dominant/subdominant cover and substrate type, cover abundance, and location), and describing stream morphology.

FHAP were conducted at representative sites for stream reaches (Johnston and Slaney 1996). FHAP involved differentiating the stream into separate habitat units such as riffles, cascades, glides, and pools and then recording an array of habitat attributes for each unit. These attributes included data on substrate composition, cover for fish, and fish habitat type.

Table 5.1-1. Conceptual Compensation Techniques

Concept Number	Target Species	Target Life Stages	Target Habitat	Primary Objective	Secondary Objective	Physical Technique
1	CO,DV,RB/ST,BT	Fry, Parr, Adult	Off-channel rearing, Overwintering habitat	Enhance/create overwintering and rearing habitat in off-channel areas by modifying ponds, beaver dams, wetlands, small floodplain tributaries to create low velocity, deep ponds with channels and complex woody debris cover	Combine spawning sites within outlet channels to seed habitat	Excavate ponds, join existing ponds with channels, or berm flow to backwater areas to create/enhance deep winter refuge habitat along floodplain at low risk of damage from mainstem, dig around beaver dams to create fish access
2	CO,DV,RB/ST,BT,CH	Fry, Parr	Side-channel rearing	Enhance/create rearing habitat in side-channels exposed to mainstem flows	-	Extend existing side channels and construct new side-channels with regulated water intakes; add complex with woody debris, boulder clusters and scour structures to increase fry/parr shear zones, slow areas and abundant cover, particularly if clear tributary flows into side-channel
3	CO,DV	Adult	Tributary/side-channel spawning habitat	Improve existing spawning habitat with cover and flow management	-	Add woody debris and boulder cover to marginal spawning areas which are deficient in cover to increase complexity of habitat and reduce predation, possibly manage flows into side-channel areas for better spawning success
4	CH,CO,RB/ST,BT,SK	Fry, Parr	Mainstem overwintering and summer rearing habitat	Enhance/create overwintering and rearing pools with increased cover	Enhance/create holding pools for adults with possible spawning areas in tailouts	Create pools by backwatering with rock riffles (less than 15 m channel width) or using lateral wood structures to scour riffles/glides into pools; add wood debris and coarse substrate for cover
5	CH,RB/ST,BT	Fry, Parr	Mainstem summer rearing habitat	Enhance/create improved rearing habitat in glides/riffles with boulder clusters for cover	-	Add boulder clusters for cover in cover-deficient, moderate gradient areas
6	CO,DV,RB/ST,BT	Fry, Parr, Adult	All habitats with obstructed access (i.e., beaver dams)	Restore fish access to existing habitat through improvements	-	Restore fish access through beaver dams with various techniques
7	DV,RB,BT	Adult	Spawning habitat	Improve/create spawning habitat with gravel placements	Improve invertebrate production in gravels	Add gravel to inlet/outlet streams and/or gravel rentention structures to improve abundance and quality of spawning area
8	DV,RB,BT,CO	Fry, Parr	Lake rearing and overwintering habitat	Improve littoral habitat around lake	Improve invertebrate production	Use helicopter to deposit woody debris into lake shore and anchor around margins of lake to improve cover
9	All species	Fry, Parr, Adult	Riparian rehabilitation	Improve riparian function adjacent to streams	-	Use forest management practices within the riaprian zone to promote release of coniferious trees and provide LWD recruitment

Dashes indicate not applicable

Species:

CO - coho salmon, CH - Chinook salmon, SK - sockeye salmon, DV - Dolly Varden, BT - bull trout, RB - rainbow trout, ST - steelhead

SHIM was conducted at certain streams and off-channel wetlands. The SHIM method is intended as a standard for watercourse and fish habitat mapping in BC (Mason and Knight 2001). This method attempts to ensure the collection and mapping of reliable, high quality, current, and spatially accurate information about fish habitats and watercourses. Streams and wetlands were located in the field and their precise locations were mapped with a differential GPS unit. Moving in an upstream direction, streams were mapped, barriers were identified, and habitat assessments were conducted. Detailed fish habitat data were collected in the field as streams and wetlands were mapped. The spatial data were tied to fish habitat data collected in the field. Collected habitat data were a combination of the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001) and *Fish habitat assessment procedures. Watershed Restoration Technical Circular No. 8* (Johnston and Slaney 1996) data.

Spawning assessments were conducted at certain sites depending upon the site-specific objectives. Target species for spawning assessments included: Dolly Varden, bull trout, chinook salmon, coho salmon, sockeye, and rainbow trout/steelhead. Spawning assessment enumerated the abundance of spawners, timing, and location of spawning habitat.

Open water wetland habitat was qualitatively described and mapped either through SHIM or on aerial photography. The width and length of open water wetland habitats were measured, maximum water depth was recorded, and amount of cover and dominant cover type were recorded. Connectivity between wetlands and streams were documented. Professional expertise was used to rank habitat suitability for each fish life history stage (i.e., spawning, rearing, overwintering) and overall habitat quality.

For lake habitats, shoreline and littoral zone substrates were mapped and categorized with a hand held GPS and an inflatable boat. Shoreline and littoral zone substrate segments were categorized by dominant and subdominant substrates present. Shoreline type was described and categorized by one of the following types: beach, low-rocky, cliff/bluff, wetland, and vegetated (mixed, shrub, coniferous, deciduous). Extensive submergent and emergent vegetation beds were described and mapped with a hand held GPS. Cover and fish habitat were described for the lake. Inlets and outlets were located, photographed, and described.

Wetland and stream overwintering habitat sites were located in the field based upon the previous field seasons site assessment data. For each wetland and stream habitat site, snow and ice thickness was measured (to the nearest 1 cm) with a tape measure and/or measuring ruler. Water depth was measured (to the nearest 1 cm) with a measuring ruler. Dissolved oxygen (mg/L) was measured with an YSI meter.

5.2.3 Fish Community

Streams were sampled using backpack electrofishers and minnow traps following RISC *Fish Collection Methods and Standards* (RISC 1997), *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001), and the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Fish Collection Field Guide* (RISC 1999b). Electrofishing site length and effort varied depending upon the site-specific objectives. Mark-recapture and single pass electrofishing techniques were used depending upon site objectives. Biological data (fork length, weight, age structures) were collected in a standardized manner, including the identification fish life history stages (i.e., fry [0+], parr [1+], parr [2+], and adult).

The fish community in wetlands were sampled using baited minnow traps set in open water habitats for a period of approximately 24 hours. Fish caught were processed in a standardized manner.

Lakes were sampled with RISC standard sinking gillnets and baited minnow traps. Gillnets were set randomly throughout the lake for a period of one hour to minimize fish mortality. If an unacceptable level of fish mortality was achieved, then the duration of net sets was shortened. If no fish were caught with one hour net sets, then the duration of the net sets was lengthened. Minnow traps were randomly set in the littoral zone (less than 2 m) along the lake shoreline overnight. Fish caught were processed in a standardized manner.

6. Proposed Compensation Projects

6.1 COMPENSATION CONCEPTS

The proposed compensation projects will combine several concepts applied in different physical settings (i.e., off-channel, mainstem, lake). The concepts are listed below and are described in the following sections:

- Concept 1 - Off-channel overwintering habitat enhancement;
- Concept 2 - Side channel rearing habitat enhancement;
- Concepts 3 and 7 - Spawning habitat enhancement and creation;
- Concepts 4 and 5 - Using wood, boulders, and pools to enhance rearing and overwintering habitat;
- Concept 6 - Improve fish access;
- Concept 8 - Enhance littoral habitat in lakes; and
- Concept 9 - Riparian function enhancement.

6.1.1 Concept 1: Off-channel Overwintering Habitat Enhancement

6.1.1.1 Rationale and Objectives

Off-channel habitat is present within and outside of the fish and aquatic habitat study area, particularly along the floodplains of Treaty and Teigen creeks, and the Bell-Irving, Bowser, and Unuk rivers (Rescan 2010, 2011b). Off-channel habitat includes beaver ponds, side channels, wall-base channels, small tributaries and relic overflow channels along floodplains (Plates 6.1-1 and 6.1-2). These features typically have low seasonal flows, well-developed riparian communities, beaver dams, and a low to moderate risk of flooding from mainstem creeks. These characteristics result in productive rearing, overwintering, and a minor amount of spawning areas for salmonids (Lister and Finnigan 1997; Solazzi et al. 2000; Rescan 2007, 2011a, 2012a).

Off-channel habitat in the fish and aquatic habitat study area is used for summer rearing and overwintering by the target species, Dolly Varden, and juvenile coho salmon (Plate 6.1-1; Rescan 2010, 2011a). Saldi-Caromile et al. (2004) reported that few records exist of Dolly Varden and bull trout use of side channel and off-channel habitat, although fish sampling in the fish and aquatic habitat study area and other northwest BC localities indicates extensive use of these habitat types (Rescan 2007, 2009, 2010, 2011a, 2012a, 2012b).

The enhancement and creation of off-channel rearing and overwintering habitat is a key component of the proposed compensation projects for several reasons (Table 5.1-1). Overwintering habitat is commonly a limiting factor and a population bottleneck for juvenile salmonids, particularly for coho salmon (Sandercock 1991; Cunjak 1995; Lister and Finnigan 1997; Solazzi et al. 2000). By targeting limiting habitat in certain concepts (e.g., off-channel overwintering habitat), substantial gains in production of coho salmon and Dolly Varden are anticipated (Ward 1997).

Off-channel pond and channel construction is a technique that has been successfully used in BC for the past 25 years, particularly when projects are designed well and maintained regularly (Slaney and Martin 1997; R. Finnigan, pers. comm.). Watershed restoration practitioners built many successful

projects over the past two decades (P. Slaney, pers. comm.; Slaney and Martin 1997). Off-channel sites are exposed to much lower stream flows and are less at risk of flood damage than mainstem sites, resulting in higher likelihood of success.

Plate 6.1-1. Off-channel beaver ponds containing all life stages of Dolly Varden in the Treaty Creek Watershed.

Plate 6.1-2. Off-channel beaver ponds containing all life stages of Dolly Varden in the lower Teigen Creek Watershed.

Construction of off-channel projects is typically less costly per unit area compared to mainstem techniques like riffle construction (Lister and Finnigan 1997). This is because of the cost efficiency of excavating ponds or backwatering large areas with berms (Lister and Finnigan 1997; P. Slaney, pers. comm.). Another reason off-channel projects are attractive for development is that more opportunities exist to create off-channel habitat on floodplains (low risk) rather than in more dynamic, higher risk mainstem settings. Roni et al. (2002) reviewed many habitat rehabilitation projects; off-channel and side-channel projects have moderate and high chances of success even though variability in success was high. Monitoring and adaptive management are two key elements required for long-term success of off-channel projects.

A key aspect of enhancing or creating overwintering habitat in streams, side channels and off-channel areas is to provide a relatively high amount of cover (i.e., over 20%). As noted in HSI models, high cover ratings provide greater suitability and higher value to fish (Table 3.2-1). Design targets of 30% (ponds) to 50% (channels) cover were used for the proposed sites. This is important because the amount and composition of cover for coho salmon (i.e., LWD) is positively correlated with higher overwinter survival and density (Bustard and Narver 1975; McMahon 1983; Tschaplinski and Hartman 1983; McMahon and Hartman 1989).

The primary biological objective for this concept is to enhance and create rearing and overwintering habitat in channels, pools, and ponds for Dolly Varden and coho salmon. Rainbow trout will likely see a small benefit from the new habitat based on their low abundance in existing off-channel areas (Rescan 2011a). Substantial overlap in technique and benefits will arise from this off-channel concept, which focuses on pond creation, and the side-channel concept, which focuses on summer rearing habitat (described in the following section). A secondary benefit will be the provision of spawning habitat in tailouts and runs among the new channels; provision of spawning habitat is compensation Concept 3 and is discussed in the following sections.

The biological objectives will be accomplished by constructing ponds, berms, water intakes, and small channels along the floodplains of larger streams. New ponds will be excavated or existing ones deepened and enlarged. Berms will be built to create backwatered ponds connected by small channels. Inlet channels will intercept groundwater, and side channels will carry surface water from small tributaries and surface intakes.

Water supply is a critical limitation on off-channel areas, and perennial sources of water will be captured to ensure fish access into new, permanent habitat. Several proposed projects are a combination of off-channel and side-channel concepts and include surface water intakes along main streams as well as large pond complexes.

Dolly Varden and coho salmon are anticipated to make extensive use of new off-channel ponds and side channels for rearing and overwintering based upon several factors:

- documented extensive use of off-channel areas for rearing, overwintering and spawning in the study area (Rescan 2010, 2011a, 2012a) and other mining projects (e.g., Galore Creek Project; Rescan 2007);
- professional experience with designing, constructing and monitoring off-channel projects (e.g., watershed restoration projects in northwest BC and Vancouver Island);
- past success of off-channel habitat creation across BC (Lister and Finnigan 1997; Slaney and Martin 1997); and
- off-channel and side-channel habitat features fit the habitat preferences of coho salmon and Dolly Varden.

The proposed off-channel and side-channel compensation sites within and outside of the study area will result in a substantial increase in production of coho salmon and Dolly Varden. Published estimates of production benefits from off-channel ponds vary depending on the species and size of ponds (Keeley and Slaney 1996; Lister and Finnigan 1997; Saldi-Caromile et al. 2004). For example, constructed off-channel ponds supported an average of 1.01 juvenile coho fry per m^2 (Keeley and Slaney 1996). Based upon 1995 survival rates and 1.01 fish/m^2, the estimated production resulted in an estimate of 68 adult coho per 1,000 m^2 (i.e., 0.1 ha; Keeley and Slaney 1996). Coho smolt production from 93 Washington State off-channel projects ranged from 0.2 to 1.0 smolts/m^2 and averaged 0.44 smolts/m^2 (Saldi-Caromile et al. 2004). Pond size is another factor affecting overall pond production, with small ponds more productive per unit area than larger ponds (Keeley and Slaney 1996).

6.1.1.2 Design Description

General

Design issues and considerations detailed in Lister and Finnigan (1997) and Saldi-Caromile et al. (2004) were consulted during the planning and design phase. The preferred habitat attributes for Dolly Varden and coho salmon in HSIs were also reviewed and incorporated into site designs (Section 3).

Key habitat variables, which can be controlled with new construction or enhancement of existing habitat include: percent cover, substrate composition, gradient, percent pools, vegetation index (several years after construction), pool/riffle ratios, discharge (to some degree), and velocity (related to gradient). Several habitat variables used in HSI models are difficult to control or alter from the ambient conditions (e.g., dissolved oxygen, flow, temperature, pH, and conductivity). For example, little modification of the dissolved oxygen content is possible in a typical flowing stream as it is generally fully saturated. In ponds, dissolved oxygen content and temperature vary depending on ice cover, depth, macrophyte decomposition, and water column mixing.

Key factors considered during the assessment and design phase included:

- water quality (e.g., dissolved oxygen concentrations, turbidity);
- winter ice cover;
- soil conditions;
- existing habitat features and productivity;
- proposed pond and channel shapes and depth;
- flows and water sources;
- habitat preferences of target species;
- presence and access of the target species; and
- beaver issues.

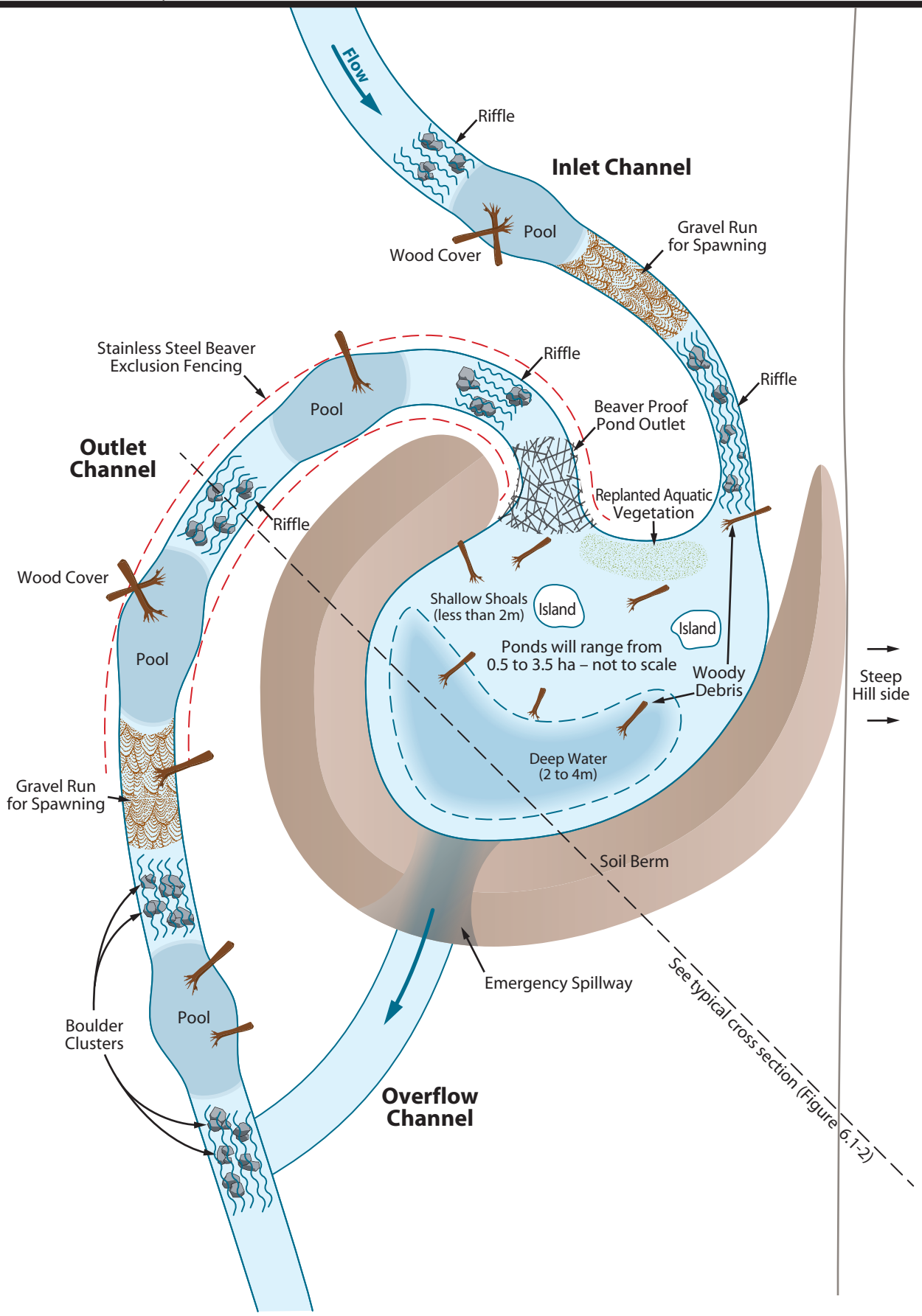
The typical off-channel project includes the following features:

- water supply (i.e., groundwater seepage and/or surface channel);
- a series of narrow channels;
- flood protection measures (e.g., gravel dike); and
- an outlet to a larger stream.

Development, design, and construction of off-channel and side channel sites share similar techniques and approaches. The off-channel design discussion below focuses on the pond components. Narrow channels will be constructed between ponds for fish access and to supply water to ponds. Typical channel details are discussed in Section 6.1-2 and are shown in Figures 6.1-1 to 6.1-4.

Ponds

Off-channel ponds for the compensation projects will range from 0.1 to 3.5 ha (Figures 6.1-1 and 6.1-2). The ponds will have a combination of features, depth, and cover to provide a complex physical environment that will maximize rearing and overwintering habitat quality for the target species. Pond features will include islands, LWD, shallow shoals, deep holes, salvaged vegetation, and variety of soil types.

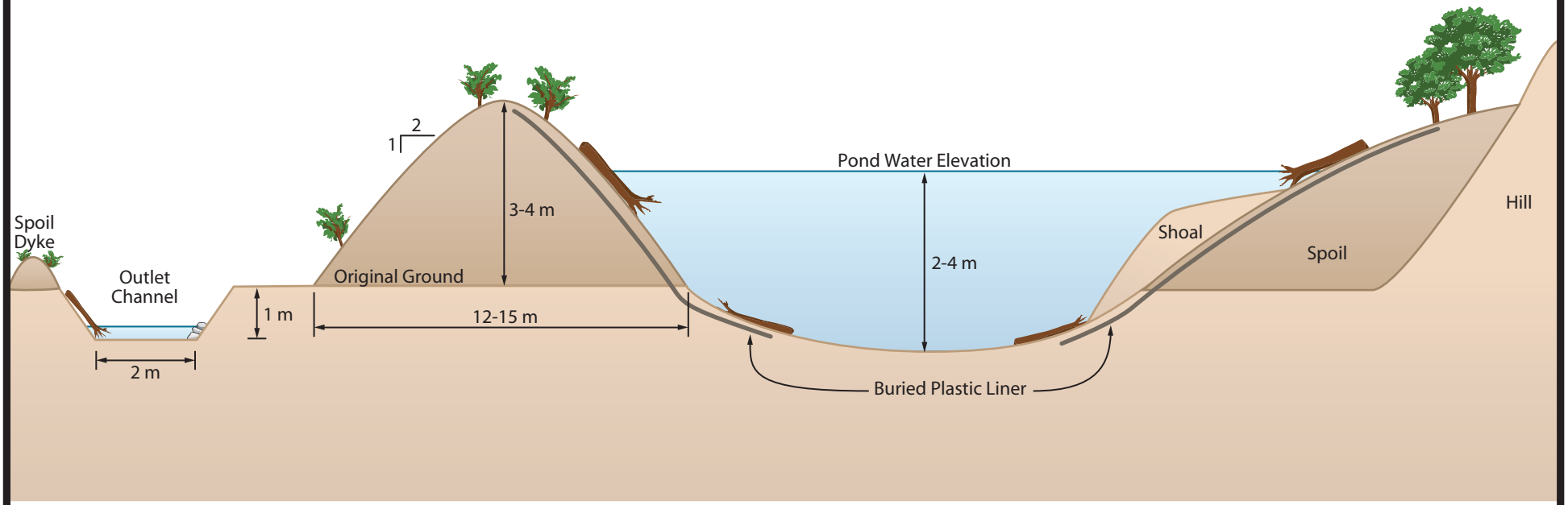


Typical Layout of a Bermed Pond and Channels

SEABRIDGE GOLD

FIGURE 6.1-1

Rescan™



Not to scale

Typical Cross-section of a Bermed Pond and Outlet Channel

FIGURE 6.1-2

SEABRIDGE GOLD

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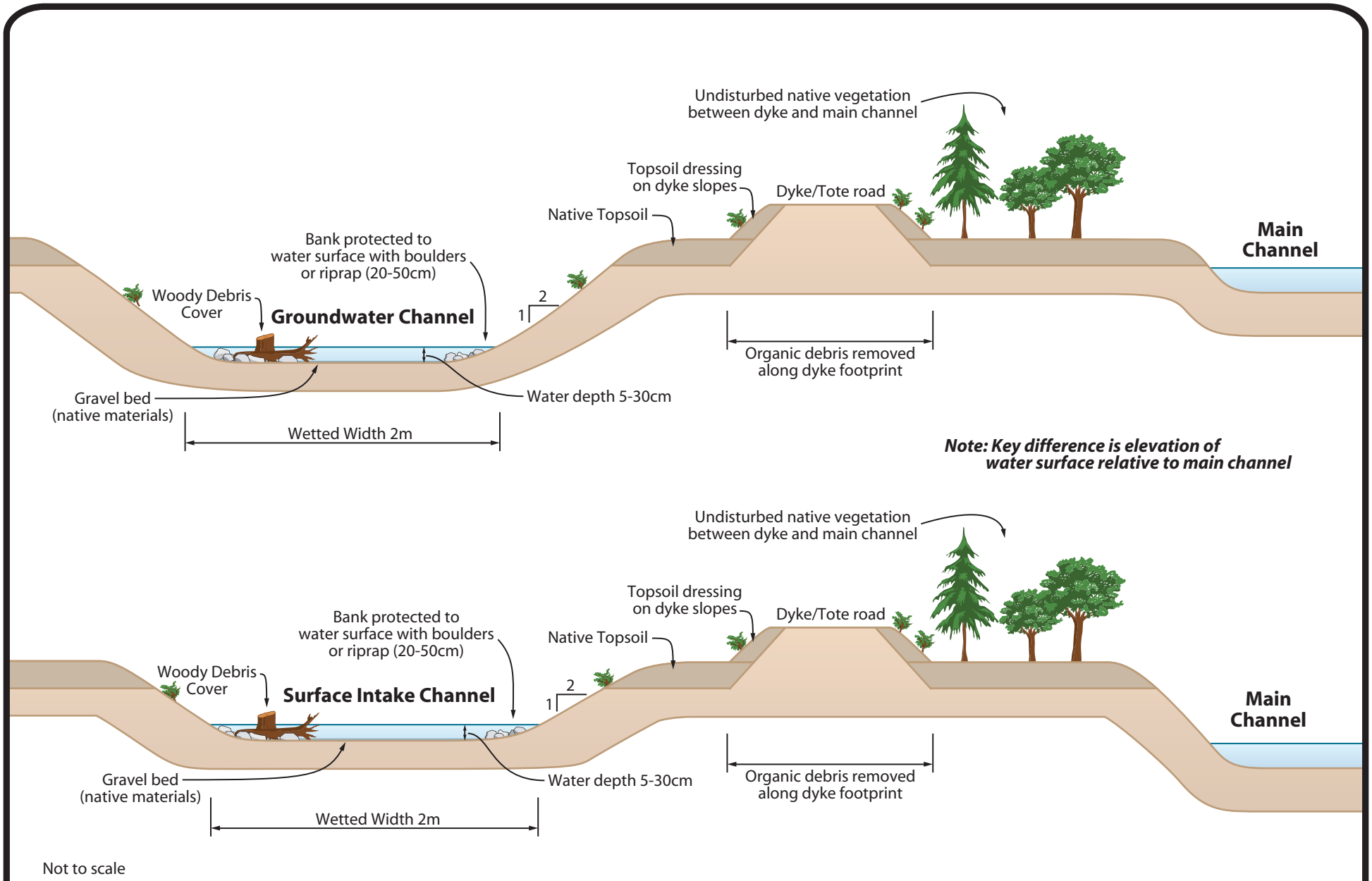

Typical Cross-sections of an Excavated Groundwater Channel (top) and Excavated Surface Intake Channel (bottom)

FIGURE 6.1-3

SEABRIDGE GOLD

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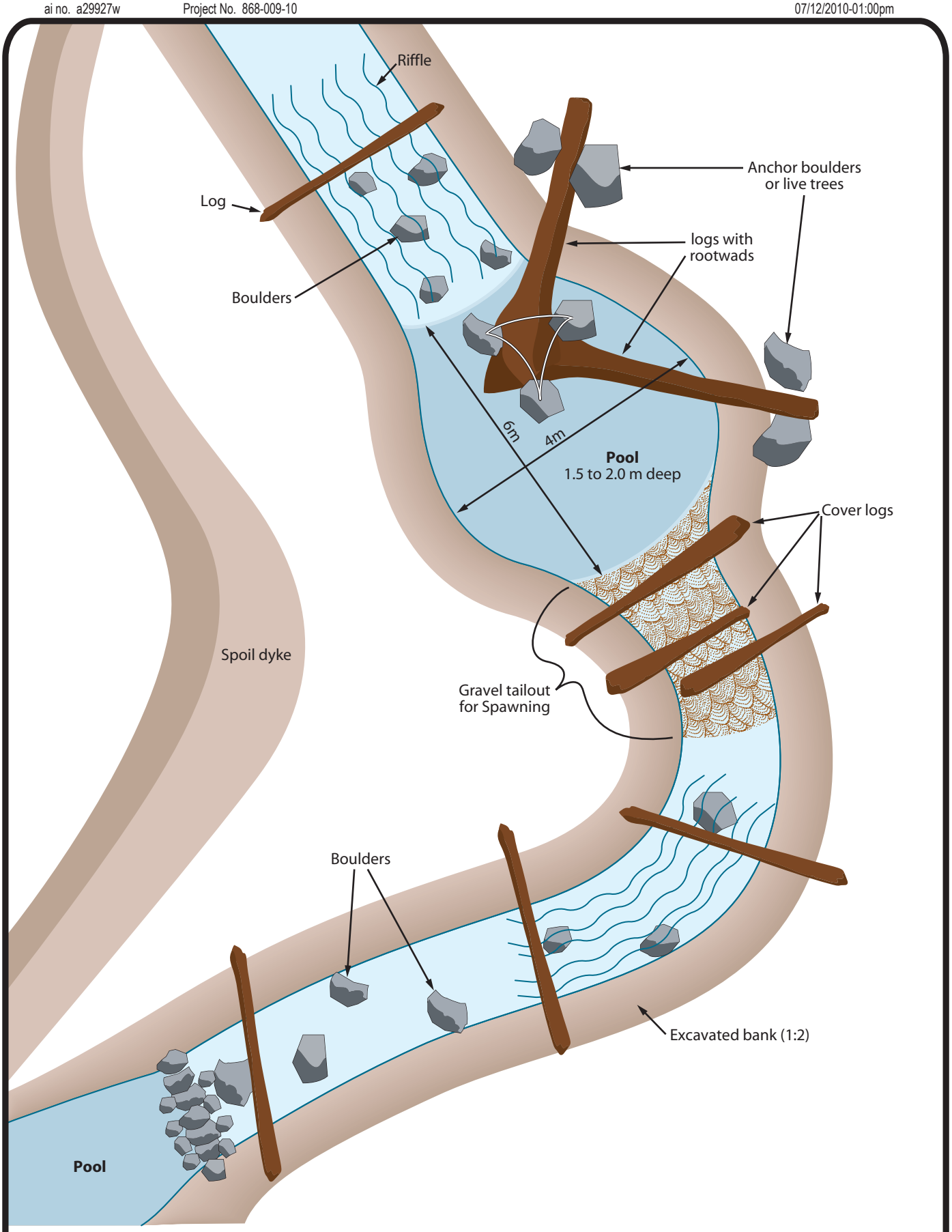

FIGURE 6.1-4

Typical Layout of an Excavated Channel with Pools

SEABRIDGE GOLD

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The complex shape and features in ponds are intended to maximize the littoral area for invertebrate and aquatic plant production as well as fish foraging, cover, and deep refuge value. Each pond will be fit to the local topography, and prior to construction, existing aquatic features and fish will be salvaged (e.g., sedge vegetation, LWD).

Two types of ponds will be constructed: excavated ponds and bermed ponds. The two pond types are differentiated by the amount of excavation and position of the water surface (Figures 6.1-1 to 6.1-3).

Key factors concerning excavated ponds are summarized below:

- pond areas range from 0.1 to 0.5 ha (i.e., much smaller footprint than bermed ponds) and from 25 to 100 m in diameter;
- ponds will be excavated into the floodplain soils with water elevation below the surrounding land (Figure 6.1-3) with one inlet and outlet;
- pond depth is typically set several metres below the lowest groundwater elevation hence monitoring of the sub-surface water table with piezometers and stand pipes is critical;
- spoil areas are situated immediately adjacent to ponds; while not integral to the pond design they will be re-vegetated or used as flood protection dikes;
- higher cost per square metre of pond than bermed ponds due to spoil handling;
- supplied by surface and/or groundwater and will not subside if excavated into water table;
- can be built at many more locations than bermed ponds due to the small size and reliance on groundwater; and
- requires medium to large excavator.

In contrast, bermed ponds hold water up to several metres higher than the groundwater table and can be much larger. The beaver ponds found throughout the study area are examples of this concept using mud and stick dams. Bermed ponds will replace existing shallow beaver ponds.

Key factors concerning bermed ponds are summarized below (Figures 6.1-1 and 6.1-2):

- pond area ranges from 0.5 to 3.5 ha (i.e., up to seven times larger than dug ponds) with greater footprint for ponds, channels, and associated berms;
- large perimeter berms, up to 4 m high and 15 m width, hold water elevation above the surrounding land (Figure 6.1-2);
- pond depth is typically 2 to 3 m and dependent on berm height not groundwater;
- much less spoil will be generated per square metre of pond than excavated ponds;
- large bermed ponds have substantial material handling requirements;
- spoil berms are integral to successful design and must be watertight (e.g., clay capping, geotextile fabric, or impermeable plastic liner);
- lower cost per square metre than excavated ponds;
- must have constant surface water input;
- two outlets required (i.e., main outlet for fish access and emergency overflow spillway [Figure 6.1-1] armoured with rock in case outlet becomes blocked by ice or beavers);

- must have beaver control features and fencing;
- can only be built at specific and less common locations; and
- requires more heavy equipment than dug ponds (i.e., medium-size excavator, bull dozer, and possibly dump truck for efficient construction of large ponds).

Regardless of the pond type, the attributes and target amounts of fish habitat features will be similar. The average water depth in ponds will range from 1.5 to 2.5 m with maximum depths between 3 and 4 m (Figures 6.1-1 and 6.1-2). Ice thickness in Treaty Creek off-channel areas in winter 2010 were up to 1.2 m (Rescan 2011c). Ponds with inflow streams or groundwater seepage in winter had thinner ice and were ice-free longer in the study area (Rescan 2011a, 2012a). Therefore, ponds will be constructed so that at least one half of the pond area will provide winter refuge habitat with at least 1 m of water below ice. A constant inflow of seepage or surface water to the ponds in winter is important for reducing ice thickness, maintaining fish access, and increasing dissolved oxygen levels.

A target for the amount of shoal area (i.e., gently sloping littoral area) at each pond will be between 25 and 50% of the pond (Figure 6.1-1). Abundant littoral areas with small islands will increase habitat quality due to aquatic vegetation colonization (e.g., sedges) and benthic insect production (Lister and Finnigan 1997). A target of 35% of each pond will be complexed with cover features. This is because high cover abundance is related to high juvenile fish density of off-channel areas (Johnson and Slaney 1996; Lister and Finnigan 1997). These features will include replanted aquatic vegetation and LWD salvaged during site preparation.

Ponds will help improve water quality by settling out fine particulate matter (i.e., suspended sediments). Silt deposited into ponds will contribute to aquatic and riparian soil formation and nutrient cycling. Siltation is not anticipated to result in excessive pond infill and degradation of fish habitat.

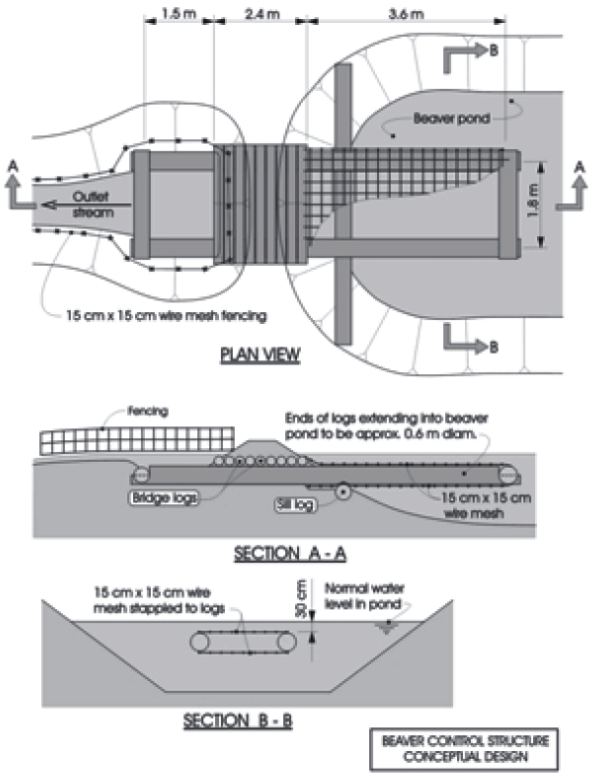
The inlet streams to each pond will have alternating riffle and pool sections. They will be complexed to provide maximum rearing and foraging habitat value (Figure 6.1-1 and 6.1-4). This is important since juvenile coho salmon growth is 50% faster at pond inlets than in pond outlets. The greater growth is attributed to a higher rate of drifting invertebrate prey originating from riffle sections upstream, particularly the high abundance of terrestrial insects, compared to pond outlet locations (Rosenfeld and Raeburn 2009).

Beaver Management

Several techniques will be incorporated into the off-channel sites to prevent beavers from damaging, blocking, or altering proposed sites. Beavers are endemic to the fish and aquatic habitat study area and provide fish habitat, wetland, amphibian, and wildlife benefits so planning for beaver activity is key (Figure 6.1-5). Beaver dams are a challenge in constructed off-channel projects because the constructed ponds are preferred beaver habitat. Secondly, beaver dams, and the lack of maintenance to remove beaver dams, are key reasons for the failure of constructed off-channel projects (Finnigan and Marshall 1997; L. Reese-Hanson, pers. comm.). Monitoring and minor maintenance of all off-channel projects will be required for long-term success.

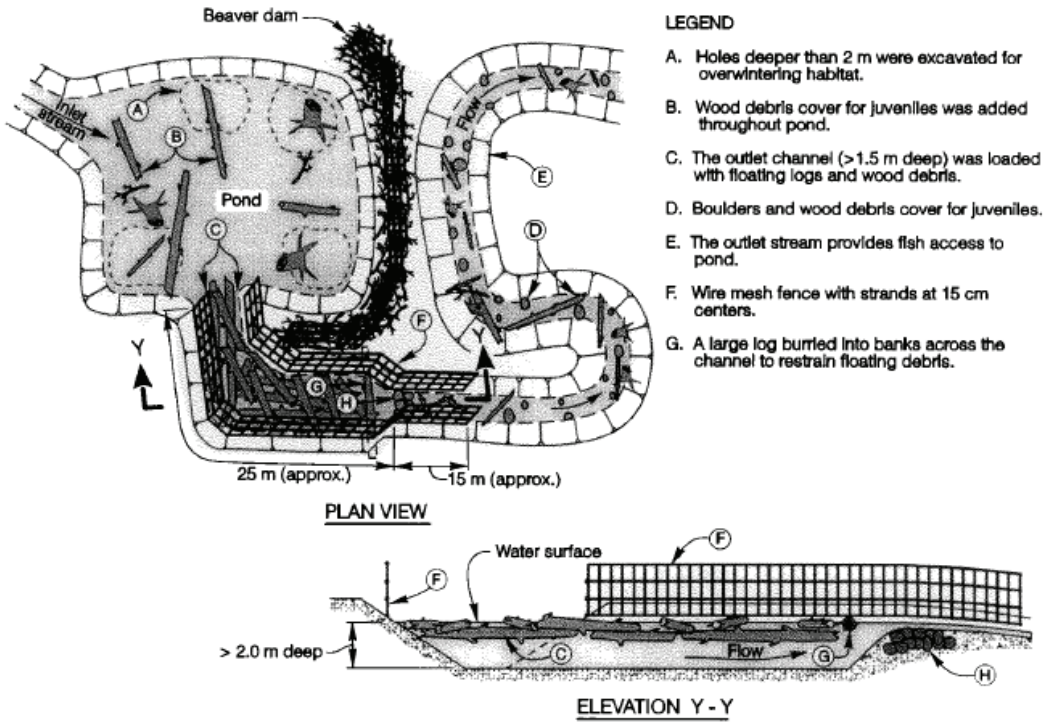
Beavers typically drag brush and branches overland from the adjacent riparian zone or swim upstream with materials to build dams. Fencing is commonly used to obstruct them, and it will be mandatory at the proposed compensation sites, particularly along excavated channels. Beaver fencing consists of wire mesh, ideally stainless steel, and steel fence posts installed immediately adjacent to the channels and at pond outlets (Figure 6.1-5).

a) A concept design for a beaver control structure



Source: Finnigan and Slaney 2002.

b) The Telkwa design concept. The outlet stream provides fish access into the beaver pond. Wire fence and floating logs restrict beaver access to the outlet stream.



Source: Finnigan and Marshall 1997.

Beaver Management Techniques to Prevent Dam Construction at the Outlets of Off-channel Ponds

FIGURE 6.1-5

SEABRIDGE GOLD

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Another technique to obstruct beavers includes beaver baffles, LWD structures, wire screens, and fences at pond outlets to obstruct beavers and reduce the sound of flowing water (Figure 6.1-5; Finnigan and Marshall 1997; Finnigan and Slaney 2002). The outlets of the proposed ponds will incorporate these features (i.e., beaver baffles, plywood levelling boxes and structures of log debris and wire mesh [Figure 6.1-5]).

Vegetation

After construction of off-channel and side channel projects, riparian enhancement will be completed to establish vegetation along disturbed areas. In addition, riparian and wetland vegetation are expected to naturally colonize the margins of ponds rapidly and contribute to ecological function. The vegetation will help establish complex ecological processes (e.g., food production, invertebrate habitat, litterfall) and boost the fish habitat quality in off-channel and side channel sites.

Logistics

The construction of off-channel and side channel projects typically involves extensive excavation and earth moving with a variety of equipment: excavators, bulldozers, dump trucks, etc. Projects will typically be constructed during the summer months when streams and groundwater will be low and dry conditions will persist. Only a couple proposed compensation sites have or will have road access nearby. The lack of road access to several sites will require establishing new road access or airlifting equipment.

6.1.2 Concept 2: Side Channel Rearing Habitat Enhancement

6.1.2.1 Rationale and Objectives

The creation and enhancement of rearing habitat in side channels is the second main concept of compensation projects (Table 5.1-1). Concept 2 deals with summer rearing habitat in side channels in contrast to the overwintering pond habitat of Concept 1.

Side channels contain productive habitat used for rearing, overwintering, and limited spawning by salmonids (Lister and Finnigan 1997; Rescan 2010, 2011a, 2012a). They also provide refuge during peak flood events and are often connected with off-channel beaver ponds and floodplain tributaries. Side channels are dynamic aquatic environments with similar habitat features, fish species, substrate, and gradients as the mainstem.

Side channels are common along the floodplains of Treaty and Teigen creeks and the Bell-Irving, Bowser and Unuk rivers (Figure 1.1-2; Plates 6.1-3 and 6.1-4). Side channels typically carry seasonal high flows in summer and fall but often dry up or contain isolated pools in late summer and winter. Side channels are often dammed by beavers to form ponds and back flood extensive areas.

Both fish use and habitat quality in side channels are quite variable. Many side channels possess poor quality habitat with few pools and low cover since they are mostly riffles and runs (i.e., laminar fast flow; Rescan 2011a, 2012a*)*. The riffle-run morphology is often due to the lack of LWD, boulders, or meander bends, which deflect the flow to cause scour (Plates 6.1-5 and 6.1-6). The lack of cover in fast flowing, laminar channels of watersheds was found to support lower densities and lower species richness than complex side channels (Slaney and Martin 1997; Ward 1997).

Fish sampling over the past three years in the study area revealed that side channels were used for summer rearing by multiple species life stages (Rescan 2009, 2010, 2011a, 2012a, 2012b). Deep, slow velocity side channels provide overwintering refuge areas and were commonly dammed by beavers. Fry and parr chinook salmon, coho salmon, Dolly Varden, sockeye salmon, rainbow trout/steelhead, bull

trout, and mountain whitefish used side channels. Adults use side channels for spawning (i.e., coho salmon, chinook salmon, and Dolly Varden; Rescan 2010, 2011a).

Plate 6.1-3. Side channels along Treaty Creek with off-channel area on left.

Plate 6.1-4. Side channels along Bell-Irving River.

Plate 6.1-5. Coho salmon spawning in good quality gravel in East Todedada Creek. The substrate composition at spawning sites provided natural templates for planning spawning habitat enhancement.

Plate 6.1-6. Triangle wood structure that will be installed in side channels to create scour and sorting in the tailouts of new pools to enhance spawning habitat.

Unlike off-channel habitat, which is suspected to limit coho production in the fish and aquatic habitat study area, the lack of summer rearing habitat in channels has not been identified as a limiting factor. However, small channels are critical components of most off-channel projects for fish access and water supply (Section 6.1-1). Consequently, developing good quality rearing habitat in the various side

channel and connecting channels will contribute to the overall success of off-channel projects. Two types of side channels are proposed for compensation work:

- enhancement of existing side channels adjacent to mainstems; and
- construction of rock armoured surface intakes to divert water into new channels (called protected side channels). Protected side channels will be excavated across the floodplain away from mainstems and lead into off-channel ponds.

Specifically, the objectives are:

- to improve rearing habitat quality in existing side channels as measured by increased percent cover, pool area, wood abundance, and residual pool depth;
- to increase the spawning habitat quality in existing side channels through scour and sorting from structures; and
- to construct good quality rearing and spawning habitat in protected side channels.

The habitat value in side channels can be improved by adding new habitat features like wood, pools, boulders, and rock riffles as well as regulating the flow extremes (Slaney and Martin 1997). As noted for off-channel projects above, construction of side channels is also a very successful technique that has been used in watershed restoration for several decades (Lister and Finnigan 1997). Many of the same benefits of creating off-channel sites apply to side channel construction.

Juvenile chinook salmon, rainbow trout, and bull trout are not expected to use constructed overwintering ponds to the same extent as Dolly Varden or coho salmon. But the proposed side channels connecting off-channel ponds will incorporate pools, riffles, and complex features that are preferred summer rearing habitat for all five species. In other words, side channels meet their habitat requirements and will be more stable, accessible, and of higher quality than at present. Anticipated benefits of side channels are based upon benefits that are apparent at the micro-site level (e.g., the improvement or creation of individual habitat features like boulders, logs, and pools). Collectively, the creation of channels with high cover, abundant deep pools, and good flows will result in more rearing, overwintering, and spawning habitat for fish. The new and enhanced channels will increase the productive capacity in the fish and aquatic habitat study area.

6.1.2.2 Design Description

General

Two types of side channel sites will be completed as part of the proposed compensation projects;

- enhancement of active side channels situated along mainstem creeks; and
- excavation of protected intake side channels to supply off-channel ponds.

Some features of proposed side channel sites were described in Section 6.1.1 since the projects share common elements (e.g., ponds, connecting channels). They share common habitat variables but differ in the flow regime and extent of excavation.

Mainstem Side Channels

This type of compensation is enhancement of active side channels where the discharge of the mainstem flow regulates side channel water levels. Discharge, water levels, bed load movement, and

debris loads are much more variable in mainstem side channels than typical off-channel sites (Plates 6.1-2 and 6.1-4). Protected side channels will only be a few metres wide whereas mainstem side channels are up to 20 m in width. Consequently, the habitat features added to mainstem side channels will be more robust, larger in size, and have larger area of effect than the features used in protected side channels.

LWD and boulder structures will be installed to create cover, pools, and complexity. Triangle log structures, wood jams, boulder clusters and opposing triangle weirs will be added to mainstem side channels to create scour pools, provide cover, and improve rearing habitat. The specific details about these structures are discussed in Section 6.1.4. Compared to the protected side channels, relatively little excavation will be required to install structures every 50 to 100 m along the mainstem side channel.

Protected Side Channels

This type of compensation is construction of "protected intake" side channels between large off-channel ponds (Section 6.1-1). An armoured surface water intake will be constructed to withdraw water from the mainstem into a side channel and off-channel ponds (Figure 6.1-3). Protected side channels will have more reliable and a smaller range of flow since the intakes can be controlled by the shape and access. Protected side channels often intercept groundwater and will have lower flood risk than mainstem side channels (Finnigan and Marshall 1997; Roni et al. 2002).

Detailed monitoring of mainstem flows will establish the hydrograph and periods when excess flow is available for diversion. Because water is withdrawn from the mainstem to the floodplain, the potential for hydrological effects will be analyzed for the mainstem reach downstream. Potential effects are anticipated to be negligible on the mainstem since the withdrawn water volume will be small. The withdrawn water will be returned to the mainstem.

Regardless of whether a proposed site carries surface water, groundwater, or a hillslope tributary, constructed channels will possess common features and functions. Inlet and outlet channels from ponds will provide migration routes, summer rearing, overwintering, and spawning habitat as well as oxygenated water into ponds (Figures 6.1-1 and 6.1-3).

Typical channel attributes include:

- trapezoidal shape with 1.5 to 2.0 m wetted width with side slopes of 1:2 (rise : run; Figure 6.1-4);
- 0.5 to 3.0% gradient with gravel and cobble substrate;
- 5 to 30 cm water depth (excluding pool depth) and 1 to 3 m excavation into adjacent soils;
- replanted riparian vegetation and treatments to accelerate recovery of the riparian community functions;
- a protective dike and tote road between the channel and mainstem river (Figures 6.1-3 and 6.1 4);
- cobble and small boulders lining the toe of the bank to prevent bank erosion;
- high cover amounts of 30 to 50% including LWD, logs, boulders, and pools to provide complex habitat;
- high pool to riffle ratio, e.g., target of 40% or one pool every 25 m;
- abundant riffle areas for invertebrate production and aeration; and
- beaver control features and fencing.

Fish habitat features within the channel will be maximized to produce high quality rearing habitat. The channels will be complexed with salvaged materials (i.e., cobble, boulders, LWD, root wads, branches; Figure 6.1-4). At least one-third of the channel and ideally about half of the channel will have overhead or instream cover. This is important because habitat quality for stream rearing salmonids is directly related to the abundance of cover (Tables 3.2-1 and 3.2-5; Johnston and Slaney 1996; Ward 1997). Logs and root wads will be partially buried in the bank or cabled to boulders to prevent washout and displacement (Figure 6.1-4).

Pools will be excavated at regular spacing (e.g., every 25 m) along the connecting channels (Figure 6.1-4). The abundance of pools is directly related to the quality of rearing habitat (Johnston and Slaney 1996). In the typical 2 m wide channel, the pool area will account for approximately 40%. The pool area within channels will account for a minimum of one-third and up to one-half of the wetted channel area to create high quality salmonid rearing habitat, as indicated in the HSI tables (Tables 3.2-1 and 3.2-5). Wood and boulder cover features are discussed in greater detail in Concept 5. The pools will also provide sufficient depth and cover for overwintering habitat (i.e., minimum residual depth of 1 m).

Spawning habitat typically develops in pool tailouts and runs containing sandy gravel and around scour features (Figure 6.1-4). Adequate velocity, cover, and depth of water are key attributes that will be factored into channel designs (Whyte et al. 1997). The channels will contain woody and boulder structures that will scour pools. It is anticipated that frequent and viable spawning habitat will also develop in the constructed channels. Should gravel placement be necessary for off-channel or side channel projects, then the placed material will follow established recommendations (e.g., 80% of 10 to 50 mm gravel, 20% of 100 mm gravel and small portion of coarse sand 2 to 5 mm; Whyte et al. 1997).

Logistics

The construction will require extensive excavation and earth moving with a variety of equipment: excavators, back-hoes, bulldozers, and dump trucks. Projects are typically constructed during the summer months when stream and groundwater tables are low and dry conditions exist. Access for heavy equipment into proposed compensation projects will be a key planning factor. New road access will be required or construction equipment will have to be airlifted.

6.1.3 Concept 3: Spawning Habitat Enhancement and Creation

6.1.3.1 Rationale and Objectives

The mainstem channels of Teigen, Treaty, Todedada, East Todedada, Snowbank, and Oweegee creeks supply the majority of spawning habitat for large-body salmonids (rainbow trout/steelhead, chinook, coho, sockeye, bull trout). Side channels, flood channels, beaver pond outlets and small tributary streams along the floodplain are used extensively by small-body Dolly Varden for spawning and to a lesser degree by coho. Spawning habitat in off-channel settings typically consists of low to moderate gradient channels with sandy gravel substrate, overhanging cover, and riffle-run morphology with occasional pools (Rescan 2010, 2011a, 2012a, 2012b). Within the fish and aquatic habitat study area, spawning habitat quality, access, cover, and flows in off-channel and side channel areas ranges from good to poor. Spawning habitat is generally not a limiting factor within the study area although access to, and flows at, potential spawning habitat impairs the use by fish.

Dolly Varden are small-bodied fish (i.e., up to 30 cm typically for stream resident fish) and require much less space and flow for successful reproduction than coho salmon. Dolly Varden were observed spawning in silt and sand substrate in northwest BC in channels as narrow as 25 cm with mainly sand substrate (Rescan 2010). In comparison, coho salmon were typically observed spawning in deeper and wider channels with stronger flow and gravel and cobble substrate (Rescan 2011a). The quality of

spawning habitat is dictated by the size, permeability, and compaction of the substrate; proximity to cover; and the velocity, depth, and dissolved oxygen content of the stream.

Concept 3 is the enhancement and creation of spawning habitat in a variety of settings (off-channel areas and side channels to large and small systems) in conjunction with other techniques (LWD and cover addition and enhanced flows). Creation and improvement of spawning habitat will help ensure a supply of juvenile fish adjacent to off-channel and side channel rearing and overwintering sites.

The key determinants for the success of spawning habitat at a compensation project are the permanence and nature of the water supply. Spawning habitat can be maintained naturally within constructed off-channel sites, which include surface water intakes from mainstems to ensure flows persist and adult fish can gain access.

6.1.3.2 Design Description

Site-specific designs for spawning habitat have not been developed; rather the habitat preferences and suitability indexes were reviewed to identify key components to include in the design of typical off-channel and side channel projects. The specific locations for spawning habitat enhancement/creation will be identified during field assessments.

The detailed analysis will incorporate the following key elements to address spawning habitat requirements:

- channel attributes – slope (i.e., 0.5 to 3%) and width (up to 2 m);
- habitat elements - meander bends, wood, and pools for adult holding cover;
- soil conditions - gravel and cobble soils are best for natural recruitment; and
- hydrologic design targets will be set for depth, flow, and velocity for adult access and spawning as well as for overwintering egg incubation.

Key criteria to consider when designing for average or better spawning and incubation habitat for coho salmon include (Whyte et al. 1997; Table 3.2-1):

- 5.0 mg/L or greater dissolved oxygen (adult);
- 40% or greater gravel/cobble substrate;
- less than 20% fines;
- substrate from 13 to 102 mm;
- water supply;
- minimum depth of 0.18 m;
- water velocity from 0.30 to 0.91 m/s;
- mean redd area of 2.8 m^2; and
- area of spawning per pair of 11.7 m^2 (i.e., one to two pairs per typical pool).

Habitat criteria to consider when designing for average (i.e., moderate) or better Dolly Varden spawning and incubation habitat includes (Washington Department of Fish and Wildlife 2004; Table 3.2-5):

- 6.0 mg/L or greater dissolved oxygen (embryo requirements);

- less than 20% fines;
- water depth of 0.1 to 0.79 m;
- water velocity from 0 to 0.58 m/s;
- water supply;
- less than 9% gradient;
- 10% or greater cover;
- moderate (75 to 149) or better riparian vegetation index; and
- presence of pools.

If gravel needs to be imported to construct spawning habitat, appropriate guidelines will be followed. The general substrate guideline for most species of salmonids is approximately 80% of 10 to 50 mm gravel, 20% of 100 mm gravel, and a small amount of coarse sand (2 to 5 mm; Adams and Whyte 1990). Gravel should be round for spawning, since angular rock will injure spawning fish (Saldi-Caromile et al. 2004). Control features such as weirs, boulders, and LWD clusters within proposed channels will retain and sort gravels (Figures 6.1-3 and 6.1-4).

6.1.4 Concepts 4 and 5: Using Wood, Boulders, and Pools to Enhance Rearing and Overwintering Habitat

6.1.4.1 Rationale and Objectives

Concepts 1, 2, and 3 rely upon two approaches to achieve habitat quality objectives. The first approach is excavation and complexing of new channels that will carry low discharge flows and not be subjected to floods. The other approach is to add rocks and logs to create new cover and scour pool features through the river's energy. Both approaches use Concepts 4 and 5 to maintain good quality habitat for salmonids. Concept 4 is the creation of pools from the addition of wood, boulders, and rock riffles. Concept 5 is the improvement or creation of complex cover with boulder clusters in riffle settings and runs instead of pools.

Pool and cover structures (e.g., wood triangles, log/boulder jams, single logs, opposing v-weirs, rock riffles) will be added to existing side channels to improve rearing habitat (Slaney, Finnigan, and Millar 1997). Wood structures create pools, provide refuge and cover, store and trap sediment, dissipate energy, and stabilize channels (Cederholm, Dominguez, and Bumstead 1997; Slaney and Martin 1997).

Juvenile salmonids will use the cover and complex shear zones provided by LWD and boulders in a pool to defend feeding territories. In general, the greater the abundance of cover and pools in a channel, the greater the density of summer rearing and overwintering fish of all life stages (Allan and Lowe 1997; Slaney and Martin 1997; Ward 1997). Fish territory size and preferred depths increase with fish size, hence the deeper and larger a pool becomes, the higher the likelihood it will be used by multiple ages, sizes, and species of fish (Keeley and Slaney 1996). Complex cover within a pool aids juvenile fish in finding refuge from predatory adult fish, each other, and peak flows. Adult fish rely upon cover and pools when holding, and the tailout sections are commonly used for spawning habitat.

These are fundamental techniques for the proposed compensation projects and they replicate natural templates in settings throughout the study area. Pools, LWD, and boulders are widespread and are critical features of fish habitat in the fish and aquatic habitat study area (Rescan 2011a; Plates 6.1-1 to 6.1-4). Depending on the setting (mainstem, off-channel, side channel, or lake), various arrangements of boulders and wood will be used to create specific scour or cover attributes. The proven success and

adaptability of wood and boulder structures to a wide variety of channels, flow regimes, species and settings is a fundamental reason for their widespread use.

The biological objectives of concepts 4 and 5 are:

- to improve rearing and overwintering habitat quality by increasing the percent cover, pool area, wood abundance and residual pool depth in existing channels using wood structures and rock riffles (Concept 4);
- to create new rearing and overwintering habitat in constructed channels using wood structures and rock riffles to scour deep pools, create complex flow patterns and provide abundant cover (Concept 4); and
- to enhance and create abundant, high quality rearing habitat in riffles using boulder clusters for cover (Concept 5).

6.1.4.2 Design Description

General

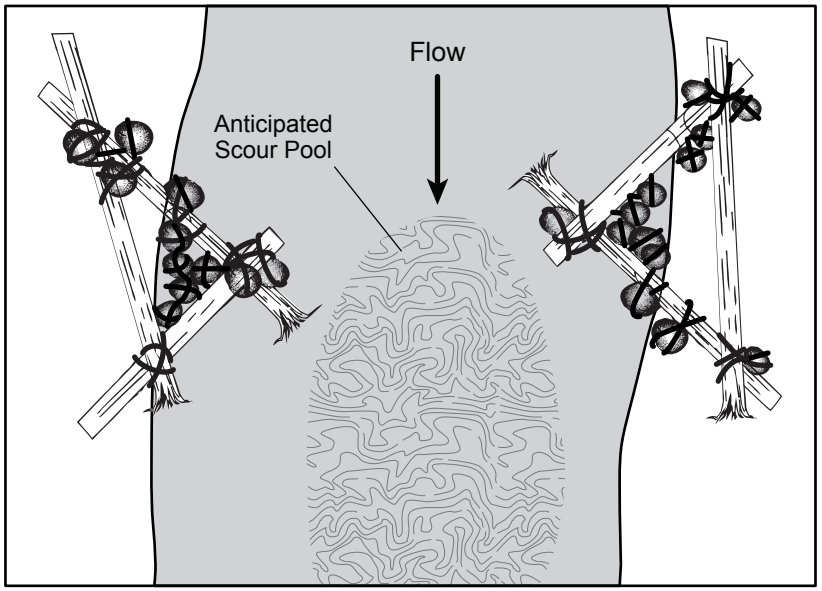
In addition to professional experience gained from designing and implementing similar projects, key design and planning criteria were reviewed including Fontaine and Merritt (1988), Slaney and Zaldokas (1997), D'Aoust and Millar (2000), and Saldi-Caromile et al. (2004). The designs will have detailed engineering, survey, geotechnical and hydrological analysis undertaken during the final design development. Key factors considered during the assessment and preliminary design phase included:

- habitat preferences of target species;
- channel morphology (gradient, width, stability, bank integrity, and disturbances);
- soil, riparian, substrate, and ground conditions;
- hydrological issues (bankfull and low flow discharge, flood regime, hydrograph);
- design templates and potential channel effects (both up and downstream);
- structure spacing and position in channel;
- ballasting requirements;
- presence and access of the target species and existing habitat features;
- constructability and equipment/crew access; and
- source of materials.

Three types of wood and boulder structures (triangle, opposing triangle, and single logs) and two types of rock structures (Newbury riffles and boulder clusters) will be constructed. Representative typical and schematic arrangements are shown in Figures 6.1-6 to 6.1-9. Each structure type is discussed briefly below.

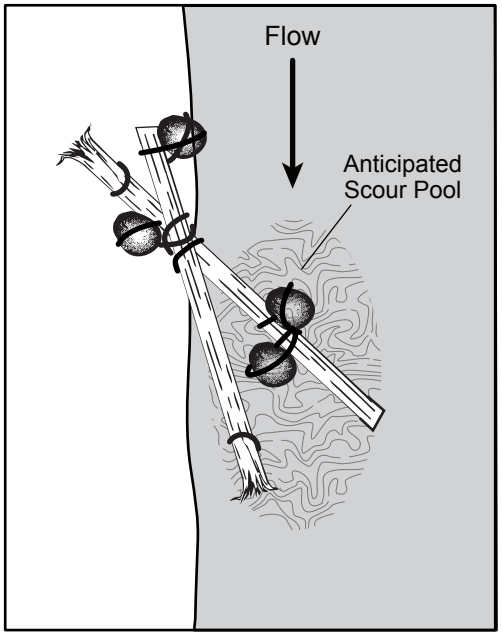
Log Triangles

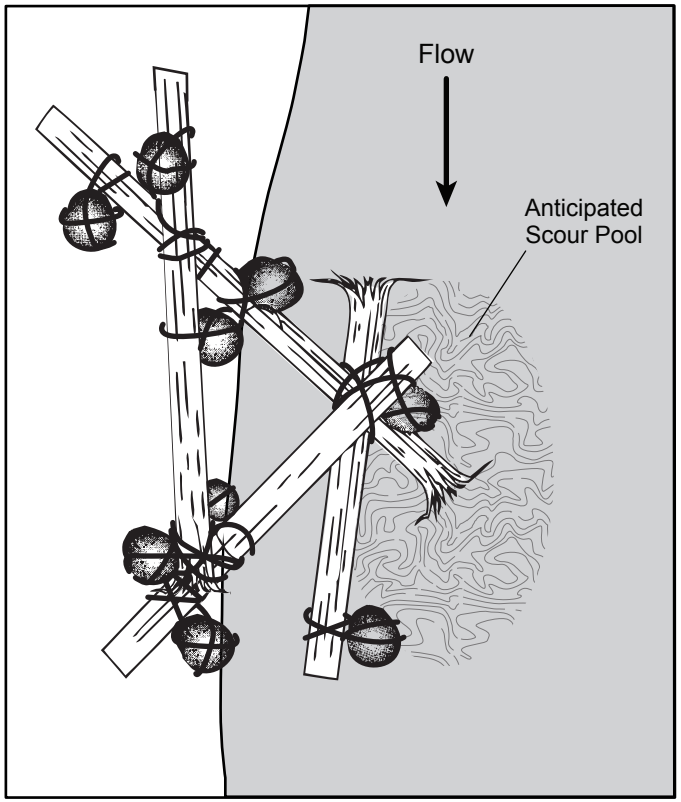
The wood structures will consist of two main types: log triangles, also called triangle log jams, and single logs (Figure 6.1-6). A third type of structure involves opposing log triangles. Structures will generally be situated on the outside of bends or in shallow wide glides. Structures will deflect the stream into the bed and banks to scour pools typically at the apex. They will replicate natural wood jams and sweepers and will protrude up to one half of the channel width. The critical outcome of these structures will be the scour pools, sorting of the substrate, as well as cover for rearing and overwintering.



Opposing Log Triangle

Double Log





Single Triangle on Outside Bend

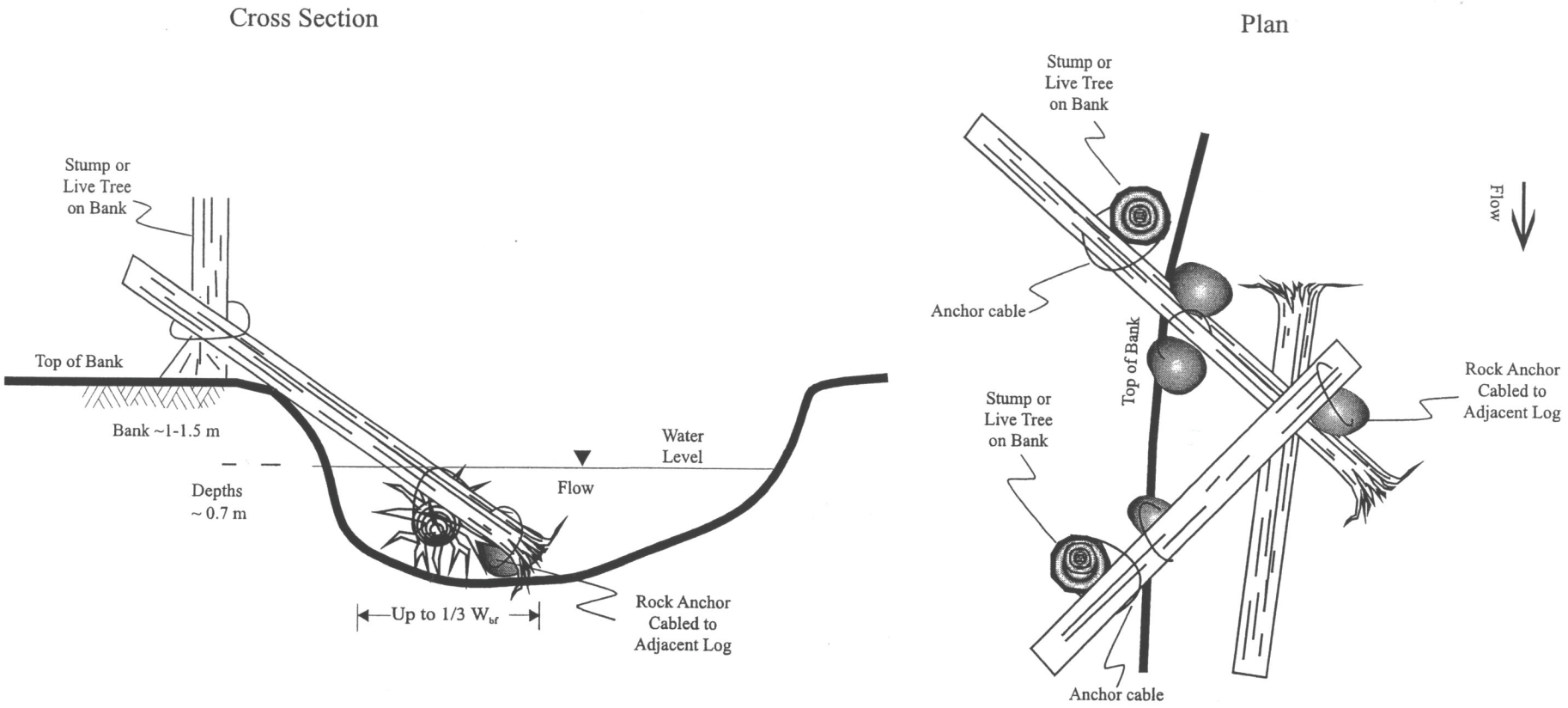
Source: Stanley and Zaldokas, 1997.

FIGURE 6.1-6

SEABRIDGE GOLD

Three Wood and Boulder Structure Templates

Rescan™



Construction Notes:

1) Use LWD pieces 8 to 15 m long x 0.5 m diameter.
2) Number and size of rock anchors depends on predicted maximum flow, maximum flow velocity and number and size of LWD used.
3) Leave cable anchors slack so that rock anchors scour into streambed.
4) If using deadman anchors instead of stumps or live trees on the bank care should be given to the positioning of the anchors to not allow the LWD to shift downstream.
5) Logs with rootwads attached to be used where available.
6) Limit LWD projection width to 1/3 of channel width or based on site conditions.

ANCHOR DIMENSIONS

Rock Required (assuming logs with rootwads):
10 - 0.8 m diameter boulders

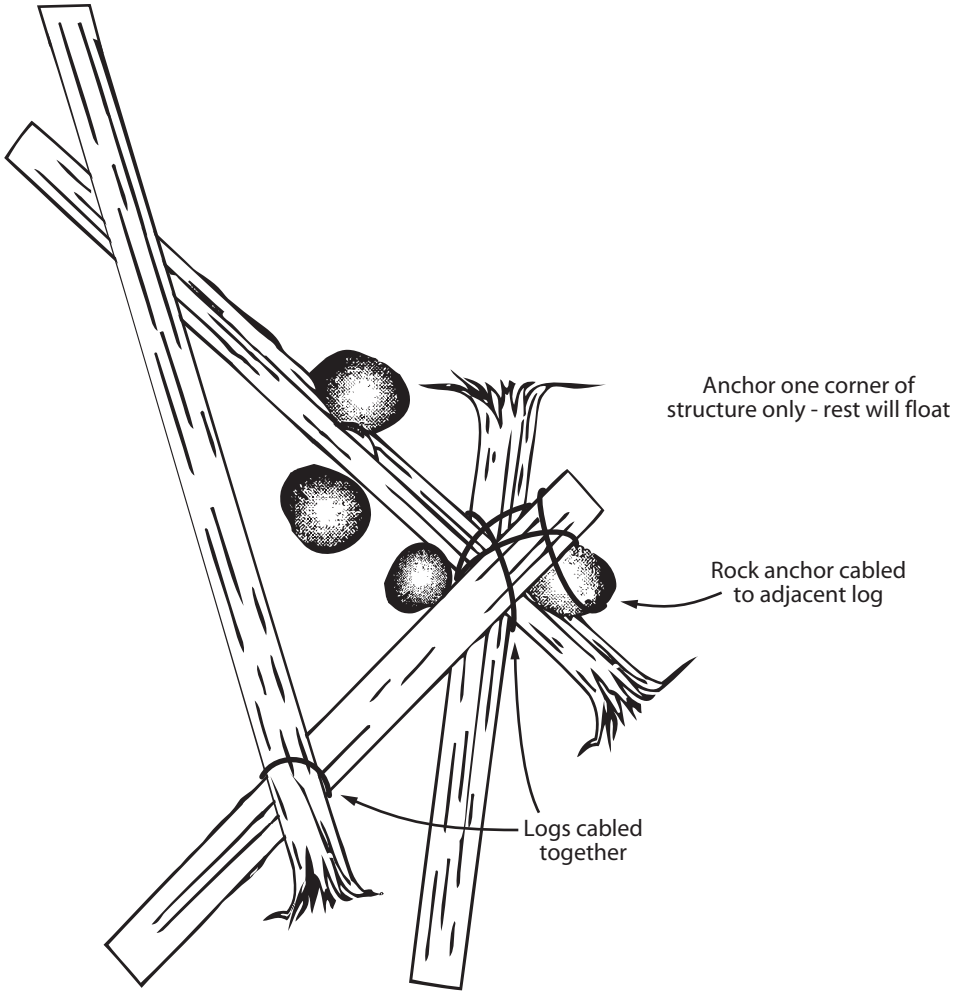
Source: Gaboury and Murray (2003)

FIGURE 6.1-7

SEABRIDGE GOLD

Typical Triangular LWD Structure

Rescan™



Construction Notes:

1) Use LWD pieces 8 to 15 m long x 0.5 m diameter.
2) Number and size of rock anchors depends on predicted maximum flow, maximum flow velocity and number and size of LWD used.
3) Leave cable anchors slack so that rock anchors scour into streambed.
4) Logs with rootwads attached to be used where available.
5) Single logs or log structures to be situated in deepest section of pond.
6) Use trees with branches and root wads attached.

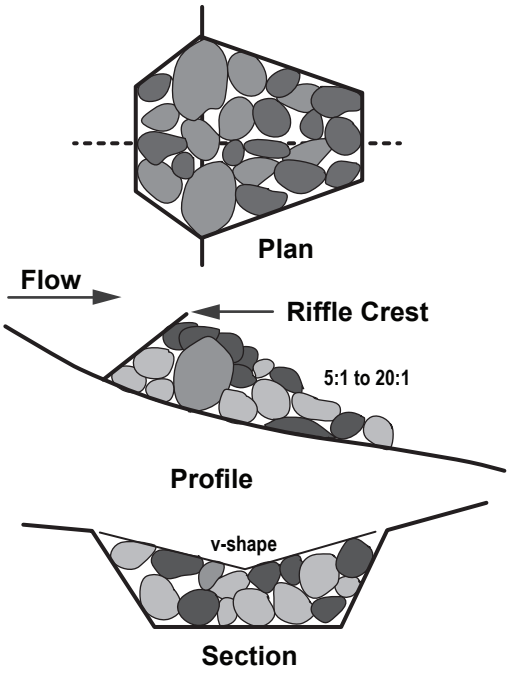
Typical Log Structure for Ponds

FIGURE 6.1-8

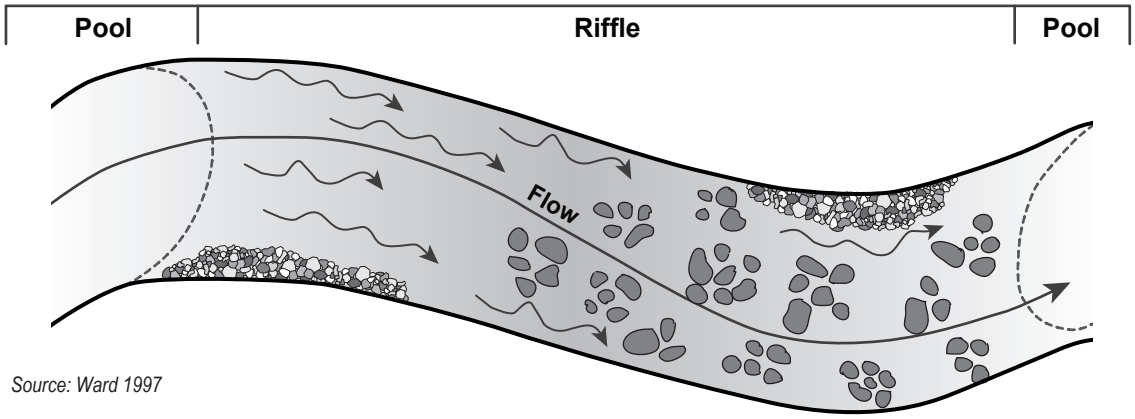
SEABRIDGE GOLD

Rescan™

1. PLAN: Build riffle crest across the stream with large diameter boulders; back up with next largest stone downstream.
2. PROFILE: Construct downstream face of riffle at a shallow re-entry slope that mimics local natural riffles (5:1 to 20:1).
3. SECTION: V-shape the crest and face downwards to the centre of the riffle (0.3 to 0.6 m).
4. SURFACE: Place large rocks randomly on the downstream face 20 to 30 cm apart to dissipate energy and create low flow fish passage channels.
5. BANKS: Rip-rap both banks with embedded boulders and cobbles to the floodplain level.



Source: Newbury, Gaboury and Bates, 1997.



Source: Ward 1997

FIGURE 6.1-9

SEABRIDGE GOLD

Newbury Rock Riffle and Boulder Cluster Layout

Rescan™

Three to four logs, 0.5 m in diameter by 8 to 15 m in length, will be cabled together to form a triangle structure (Figure 6.1-6; Plates 6.1-7 and 6.1-8). Large boulders (0.5 to 0.8 m in diameter, 250 to 600 kg) will be cabled to each corner of the structure and placed on the bank top. Rock ballasting will depend on the sizes of logs available, species, buoyancy, and design velocities. For example, typical three-log triangles of 0.5 m diameter wood by 6 m in length will require approximately 2,200 kg of ballast in total (six boulders of 350 kg; Slaney, Finnigan, and Millar 1997). Boulders will be cabled to each other with wire rope that will be epoxied approximately 30 cm into each boulder (Figure 6.1-6 and 6.1-7). This system is reliable and recommended for building durable wood and boulder structures (Fontaine and Merritt 1988; D'Aoust and Millar 2000).

Plate 6.1-7. Triangle log structure.

Plate 6.1-8. Spider-hoe constructing triangle log and boulder structure along Cheakamus River. (Used with permission – NuCreek Developments Inc.)

The log triangles will be spaced approximately every 25 to 75 m apart, depending on the channel width. Triangles will influence approximately 100 m^2 of habitat at each site while single logs will influence up to 50 m^2. Single logs will typically be installed in shallow glides and pools to provide cover in tailouts.

Opposing Log Triangles

Two log triangle structures will be built opposite each other (Figure 6.1-6 and Plate 6.1-9). They will be spaced approximately one-quarter to one-third of the channel width apart. These structures will force the flow into the middle of the channel and back water upstream. This configuration will result in a plunging effect as the water is pinched into a narrow opening between the structures and will scour a large pool. Opposing structures will be used in several systems to replace low beaver dams, which create upstream glides at present with low fish habitat value. Single trees or root wads will be added to the pools downstream to increase the cover value. Approximately 150 m^2 of habitat will be improved at each site.

Plate 6.1-9. Opposing triangle and boulder structures with large scour pool in the mid-channel.

Floating Log Triangles in Beaver Ponds and Lakes

Poor-quality overwintering and rearing habitat have been identified in beaver ponds within the fish and aquatic habitat study area, which could be improved by adding triangle structures for cover. For example, the beaver ponds along East Todedada Creek had almost no instream cover except for overhanging shrubs.

The typical log triangle will be constructed but only anchored at one end with four to six large boulders (Figure 6.1-8). Structures will be anchored on only one end so the remainder can float with fluctuating water levels and provide maximum overhead cover. The structures will have little scour function since they will be exposed to much slower water velocities in the ponds.

Newbury Rock Riffles

Newbury rock riffles are another technique that is suitable for creating pools and enhancing rearing and overwintering habitat in continuous cascade systems (Newbury, Gaboury, and Bates 1997). Newbury riffles are commonly used in channelized stream sections to backwater upstream cascade sections into alternating pool and riffle sequences (Figure 6.1-9; Plate 6.1-10). Newbury rock riffles are also proposed to be used to backwater a perched culvert to improve fish passage.

Plate 6.1-10. Spider-hoe installing a Newbury rock riffle along the Mahatta River. (Used with permission – NuCreek Developments Inc.).

Boulder Clusters

Concept 5 is the use of clusters of 0.5 m diameter boulders in small streams and side channels to improve rearing cover in riffles (Figure 6.1-9). Groups of 5 to 7 boulders will be spaced up to 1 m apart in the lower half of pool riffles and tailouts (Ward 1997). These clusters will influence up to 10 m^2 of habitat and are typically added throughout a reach (e.g., every 50 to 100 m).

Construction Considerations

An excavator or a spider-hoe will be the only heavy equipment needed to create log triangles and boulder clusters in channels (Plates 6.1-9 and 6.1-10). Heavy-lift helicopters will be needed to airlift equipment into remote sites as well as to mobilize boulders and logs to stream sites. At sites with road access, dump trucks and tracked excavators will mobilize materials and undertake construction from stream banks.

A spider-hoe is an invaluable piece of equipment for constructing instream structures, since it can walk in streams with minimal disruption, unlike a tracked excavator (Plates 6.1-9 and 6.1-10). Experienced crews, appropriate machinery and materials, and good equipment operators are needed to complete these complex projects effectively.

6.1.5 Concept 6: Fish Access

6.1.5.1 Rationale and Objectives

Beavers are present throughout the fish and aquatic habitat study area in ponds, side channels, and off-channel tributaries along floodplains (Plates 6.1-1 to 6.1-4). Beavers maintain large areas of wetlands; some of which contain fish. The height of beaver dams, lack of flow, and dispersed flows around dams typically exclude juvenile fish from using large areas of aquatic habitat in the fish and aquatic habitat study area (Rescan 2010, 2011a). In certain cases, lack of suitable outflow prevents coho smolts, which had immigrated into beaver ponds as fry, from emigrating from ponds. Fish are often located within beaver ponds upstream of the dams indicating that only partial or seasonal obstruction of fish access occurred. Adult access into off-channel areas is also blocked by dams at several sites (see Table 6.2-1).

The objective for this concept is to restore fish access into areas obstructed by beavers through a variety of techniques (e.g., channels, juvenile passage structures; see Table 6.2-1).

6.1.5.2 Design Description

Certain compensation projects have been identified in areas currently used by beavers that have excellent potential to be large compensation sites if fish access could be restored (see Table 6.2-1 and 6.2-2).

The main technique for restoring permanent fish access is to construct channels with heavy equipment around beaver dams and reinforce existing beaver dams, or remove them entirely, and install beaver proof fencing. This technique can only work under very specific conditions.

The key outcome of this concept is the recognition that the highest likelihood for overall success in providing fish access is at those sites where a combination of concepts can be used. For example, where a surface water intake will provide sufficient flows to off-channel ponds and a new outlet channel can be justified to restore fish access.

6.1.6 Concept 8: Enhance Littoral Habitat in Lakes

6.1.6.1 Rationale and Objectives

Climatic, chemical, biotic and geologic factors strongly influence productivity in lakes. Another key factor is the habitat complexity of the littoral zone, which is linked to the lake productivity through fish communities, nutrients, and energy flow (Schindler and Scheuerell 2002). Complex littoral systems provide cover and substrate and mediate the energy flow among communities. In addition, juvenile salmonids use the shallow margins of lakes, particularly at night and when emigrating from nursery streams.

The productivity of fish bearing lakes within the fish and aquatic habitat study area ranges from productive waterbodies at low elevations to nearly barren lakes at high elevations (Rescan 2009). For example, Todedada Lake contains abundant rainbow trout and complex littoral habitat (Tripp 1987; Plate 6.1-11; Figure 6.2-1). It is a small clear low elevation lake in the Todedada Creek Watershed with abundant LWD around the perimeter. In contrast, Hodkin Lake, is located on a high plateau in the upper Teigen Creek Watershed and had a low abundance of Dolly Varden when sampled in July 2010 (Plate 6.1-12; Rescan 2011a).

The objective for this concept is to increase the diversity, complexity, and abundance of woody cover in the margins of lakes (see Table 6.2-3).

Plate 6.1-11. Complex littoral zone around productive Todedada Lake.

Plate 6.1-12. Hodkin Lake with isolated population of Dolly Varden and sparse littoral zone.

6.1.6.2 Design Description

This concept involves the introduction of LWD, to be anchored to boulders and bedrock along the margins of four lakes. An increase of 10% shoreline cover will be targeted, i.e., one large triangle every 100 m of shoreline, assuming large triangles each affect about 150 m^2 of habitat up to 15 m from shore. Approximately 10% of the shoreline of each lake will be treated with a focus on the shallower basins and outlet and inlet streams.

Whole trees, trunks, and root wads (8 to 15 m in length, minimum 0.5 m diameter) will be flown via helicopter from a nearby source and deposited along the margins of the lakes. The helicopter will drop logs and rocks in triangle arrangements. Logs will be anchored with cable to boulders and bedrock as floating log triangles such that at least 75% of the structures are within the lake at low water (Figure 6.1-8).

Construction considerations are straightforward for this concept since, aside from a helicopter to move wood, no heavy machinery is required on site for moving logs. Crews would anchor and cable the structures to prevent dislodgement by wind, waves, and ice shifting. The identification of sources of rock and logs would be the primary planning activity for this concept.

6.1.7 Concept 9: Riparian Function Enhancement

6.1.7.1 Rationale and Objectives

The riparian zone is the interface between upland vegetation and soils and flowing water containing aquatic habitat (Plates 6.1-1 to 6.1-4). Riparian vegetation within this zone provides essential ecological services including shade, energy contribution (litterfall), bank stability, filtration of overland run-off, biochemical functions in the soil, and contributions of LWD. Riparian vegetation is an important component of rearing and overwintering habitat in streams and ponds. Terrestrial insects drop from overhanging vegetation into streams and ponds, while organic matter such as leaves provides a food source for aquatic invertebrates, which are in turn consumed by fish (Adams and Whyte 1990).

A wide variety of riparian vegetation communities exists along creek channels in the fish and aquatic habitat study area. Vegetation types range from sedge and shrub dominated communities in Todedada Creek to deciduous shrubs and trees in the cottonwood dominated floodplains of the Bell-Irving River. Mature coniferous forests exist along many channels and hillslopes and provide some of the most obvious examples of riparian zone function, the contribution of trees and root wads to the channel. When planning habitat compensation projects, the use of plant species native to the area is often recommended (DFO 2006). Native plant material can be grown in nurseries, collected from undisturbed areas (within reason), or salvaged from areas that will be subject to development.

Construction activities at certain fish habitat compensation projects will involve the removal of large amounts of vegetation. Rehabilitation projects will be planned to coincide with construction activities to take advantage of native plant materials that can be salvaged instead of being destroyed.

The biological objective for this concept is to rehabilitate disturbed riparian areas as efficiently as possible and accelerate the recovery of self-sustaining vegetation communities with a wide variety of techniques. Additional approaches to riparian enhancement include the treatment of naturally impaired or human-impacted vegetation and sites (e.g., logged riparian areas in cutblocks) should there be few opportunities for rehabilitating disturbed communities.

6.1.7.2 Re-vegetation Approach and Techniques

A re-vegetation plan will be developed by a qualified botanist to identify methods to salvage vegetation, areas and species, timing, storage needs, and planting techniques. The re-vegetation plan will be driven by the scheduling of both mine and compensation site construction to maximize the efficiency of salvage and transplant operations and minimize soil and vegetation exposure.

Two re-vegetation techniques commonly used in restoration activities include dormant cuttings and transplants (Babakaiff, Hay, and Fromuth 1997).

Dormant cuttings are used in restoration projects in a variety of ways, including live staking, brush layering, live siltation, brush mats, and bundles (fascines). Dormant cuttings can be harvested from living, woody plants during the winter/early spring (or during the fall if planting will occur in the fall) or purchased from nurseries. Cuttings are collected from plant species that root easily, such as willow, poplar, and cottonwood.

Live staking is often used in conjunction with other re-vegetation techniques and is an inexpensive method of re-vegetating a site. It does, however, have a lower survival rate when compared to other re-vegetation techniques. Brush mats constructed of dormant branches provide both erosion control and vegetative cover to an area. They require large amounts of plant material, which will be considered prior to their inclusion in a re-vegetation design.

Transplanting involves the relocation of a plant or plants containing roots and shoots from one area to another. Transplants can vary in size, from large vegetation mats to smaller plugs, sprigs, and single-plant transplants. All types of transplants require careful handling in order to ensure success. Transplanting can be mechanized, depending on the size of material (e.g., vegetation mats). Transplanting is a suitable re-vegetation method used for species that do not root well from cuttings.

Vegetation mats can also be propagated in a greenhouse or outdoors. The benefit of vegetation mats is that they provide an instant plant cover and also help protect the site from soil erosion.

If the introduction of herbaceous vegetation to the area is a desired goal, then the use of a vegetation mat composed of native grasses or sedges will be considered. Similarly, grass and sedge species can be fashioned into a roll, held together with biodegradable fabric and twine (Babakaiff, Hay, and Fromuth 1997). When placed along the bank, the roll provides structural protection as well as an overhanging vegetative cover. Plugs and sprigs are smaller than vegetative mats and often contain only one plant species. They can be collected from a donor location or can be grown in a nursery or greenhouse environment.

6.2 COMPENSATION PROJECTS SUMMARY

6.2.1 Project Identification

Desktop analysis and field assessments were completed for the preliminary compensation projects (Table 6.2-1). For each site, habitat limitations are summarized, biological objectives are identified, and physical techniques to achieve the objectives are summarized. The preliminary projects are located in three watershed physical settings, which are lake, off-channel/side channel, and mainstem. There are four lake littoral zone enhancement projects, 12 mainstem creation/enhancement projects, and 20 off-channel/side channel creation projects.

The locations of the preliminary projects are presented in Figures 6.2-1 and 6.2-2. The preliminary projects are located within 15 different watersheds. These watersheds include: Teigen, Hodkin, Unuk, Gilbert, South Teigen, Snowbank, Treaty, East Todedada, Todedada, Glacier, Taft, Oweegee, Mere, Bowser, and Bell-Irving.

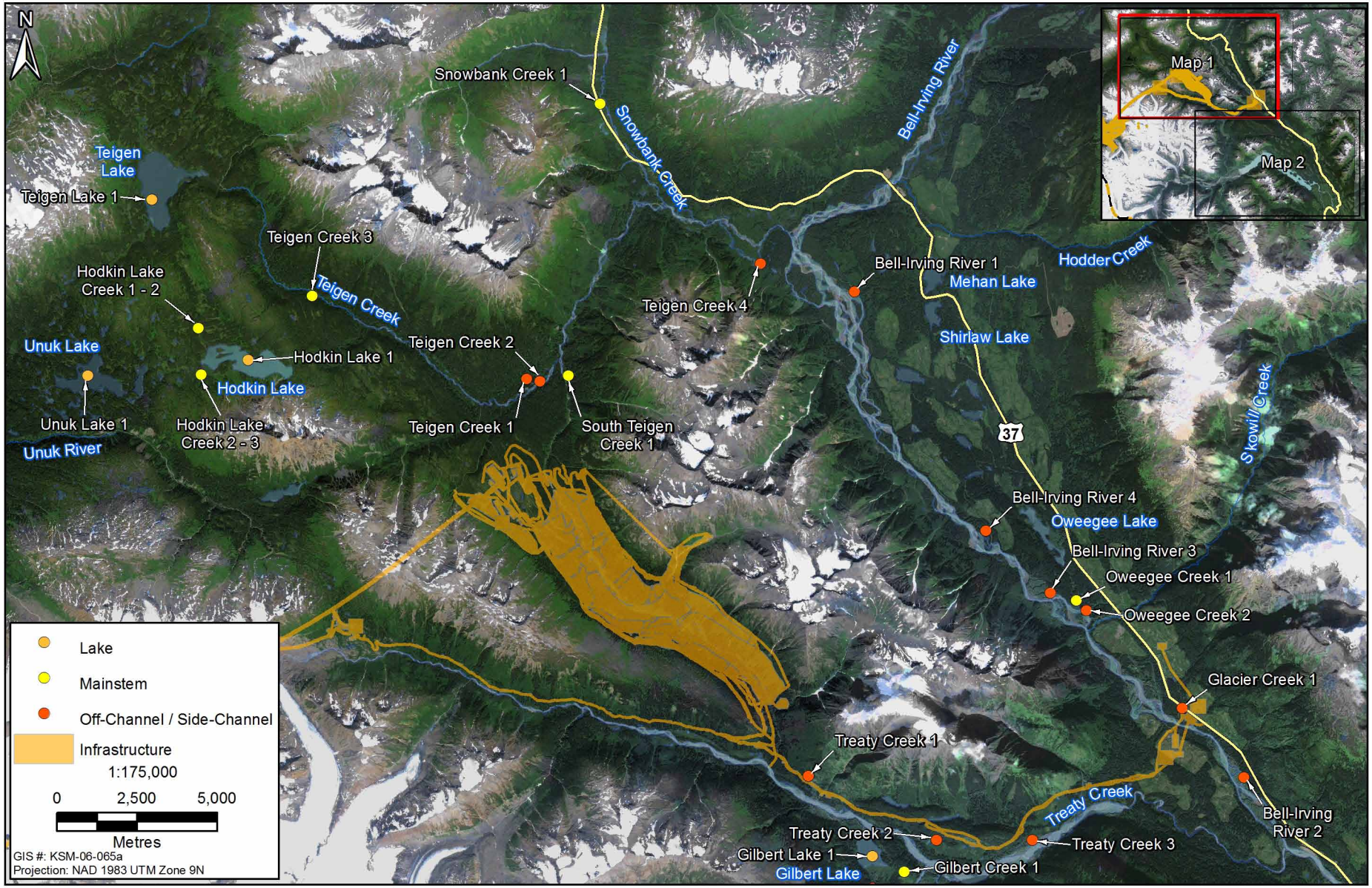


Figure 6.2-1

SEABRIDGE GOLD
KSM PROJECT

Location of Compensation Projects - Map 1

Figure 6.2-1

Rescan
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Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Teigen	-	Teigen Lake	1	Littoral zone lacks LWD rearing habitat and cover	Improve littoral zone rearing habitat cover by providing LWD	Simple, repeatable design concept. Add anchored LWD to increase overhead cover for fish rearing and refuge	8	-			X
Teigen	Hodkin	Hodkin Lake	1	Littoral zone lacks LWD rearing habitat and cover	Improve littoral zone rearing habitat cover by providing LWD	Simple, repeatable design concept. Add anchored LWD to increase overhead cover for fish rearing and refuge	8	-			X
Unuk	-	Unuk Lake	1	Littoral zone lacks LWD rearing habitat and cover	Improve littoral zone rearing habitat cover by providing LWD	Simple, repeatable design concept. Add anchored LWD to increase overhead cover for fish rearing and refuge	8	-			X
Treaty	Gilbert	Gilbert Lake	1	Littoral zone lacks LWD rearing habitat and cover	Improve littoral zone rearing habitat cover by providing LWD	Simple, repeatable design concept. Add anchored LWD to increase overhead cover for fish rearing and refuge	8	-			X
Teigen	Hodkin	Hodkin Lake Creek 1	2	Inlet creek lacks suitable spawning substrate. Low densities of mature Dolly Varden present in Hodkin Lake. Hodkin Lake productivity limited by abundance and quality suitable spawning substrate	Improve poor quality spawning habitat and increase spawning habitat by providing suitable spawning substrate and channel complexity in lower reach of creek	Add suitable spawning gravels and gravel retention structures to increase amount of good quality spawning habitat	7	-		X	
Teigen	Hodkin	Hodkin Lake Creek 2	3	Inlet creek lacks suitable spawning substrate. Low densities of mature Dolly Varden present in Hodkin Lake. Hodkin Lake productivity limited by abundance and quality suitable spawning substrate	Improve poor quality spawning habitat and increase spawning habitat by providing suitable spawning substrate and channel complexity in lower reach of creek	Add suitable spawning gravels and gravel retention structures to increase amount of good quality spawning habitat	7	-		X	
Teigen	-	Teigen Creek	3	Upper reaches of Teigen Creek dominated by cascade-pool morphology with coarse bed substrates, high velocity, and limited pool habitat. Low densities of Chinook salmon fry and low abundance of Chinook salmon spawning habitat present in upper reaches compared to mid and lower reaches. Upper reaches lacks suitable velocity refuge and rearing habitat cover, abundance and quality of suitable spawning habitat, and abundant and quality pool overwintering habitat.	Improve existing poor and fair quality summer rearing habitat velocities and overwintering habitat in upper reaches by creating pool and cover habitat. Improve poor quality spawning habitat at tailouts of pools	Repeatable design concept in appropirate hydralic conditions. Build rock riffles to backwater cascade habitat sequences to provide suitable rearing velocities, improve overwintering habitat, and create spawning habitat at pool tailouts. Add overhead cover and instream boulder clusters to improve rearing and overwintering habitat complexity.	4	5		X	
Teigen	South Teigen	South Teigen Creek	1	Lower reach of South Teigen Creek dominated by cascade habitat with coarse bed substrates, high velocity, and limited pool habitat. Creek lacks channel complexity. Lower reach lacks suitable velocity refuge and rearing habitat, suitable spawning habitat, and quality pool overwintering habitat.	Improve existing poor quality summer rearing habitat velocities and overwintering habitat in lower reach by creating pool and cover habitat. Improve poor quality spawning habitat	Repeatable design concept in appropirate hydralic conditions. Build rock riffles to backwater cascade habitat sequences and sort bed substrates to provide suitable rearing velocities, improve overwintering habitat, and create spawning habitat by retaining gravels. Add overhead cover, LWD and instream boulder clusters to improve rearing and overwintering habitat complexity.	4	5		X	
Teigen	Snowbank	Snowbank Creek	1	Reach downstream of open-water wetland and Redflat Creek is dominated by riffle-run habitat with gravel-cobble substrates, low abundance of funcitional LWD, and limited pool frequency. Creek lacks channel complexity to provide a diveristy of rearing, spawning and overwintering habitat.	Increase the abundance of functional LWD within the channel which will improve the diversity of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting	Add anchored LWD complexes to enhance rearing habitat, create pools and spawning habitat	4	5		X	
Teigen	-	Teigen Creek	1	Majority of off-channel within the Teigen Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Poor quality off-channel habitat is limiting the productive capacity for summer rearing and overwintering habitat. Availability of good spawning habitat to seed off-channel and side-channel habitat is limited.	Improve and create overwintering and rearing habitat in off-channel areas by modifying existing beaver ponds. Create series of deep ponds with LWD cover and connecting channels to ponds and side-channel habitats. Provide fish access to ponds.	Complex design. Intercept exisiting hillside stream for water supply to construct impermeable berms to backwater a series of deep ponds. Add anchored LWD complexes to ponds. Add SWD and overhanging cover, as required. Connect ponds to each other and mainstem through excavation of channel. Create channel complexity through the addition of LWD structures, gravel placement and gravel retention structures. Incorporate channels to allow fish access around/through ponds.	1	3,6,9	X		

Dashes indicate not applicable

(continued)

Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Teigen	-	Teigen Creek	2	Functional side-channel habitat within the Teigen Creek floodplain is limited in abundance. Poor quality and/or inaccessible side-channel habitat is limiting the productive capacity for summer rearing and overwintering habitat. Availability of good spawning habitat to seed side-channel habitat is limited.	Improve existing side-channel rearing and overwintering habitat in off-channel areas by adding LWD complexes. Extend existing side-channel to increase the amount of rearing and over-wintering habitat. Addition of functional LWD within the channel tol improve the diversity of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting	Complex design. Construct water intake control structure at entry of side-channel. Excavate extension of side-channel. Create chanel complexity by adding anchored LWD complexes. Provide low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades.	2	3	X		
Teigen	-	Teigen Creek	4	Majority off-channel habitat within the Teigen Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Off-channel habitat is accessible to fish limiting the productive capacity for summer rearing and overwintering. Fair quality off-channel habitat lacks LWD structure and complexity.	Improve fish passage past beaver dams to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Install beaver dam bypass channel to allow fish movement. Improve fish cover by adding cabled LWD complexes to ponds. Re-enforce beaver dams by berming dam materials.	1	9,6	X		
Treaty	-	Treaty Creek	1	Majority of off-channel habitat within the Treaty Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Poor quality rearing and overwintering habitat is present at the site. Relic beaver ponds lack complexity, water depth and fish accessibility. Availability of good spawning habitat to seed off-channel habitat is lacking.	Create overwintering and rearing habitat. Create series of deep ponds with LWD cover and connecting channels to ponds. Create spawning habitat and complexity within channel. Provide fish access to ponds.	Complex design. Divert portion of surface water from North Treaty Creek for water source. Contruct water intake control structure on North Treaty Creek. Construct berms to back up water and create a series of ponds. Excavate channels to connect ponds to each other, North Treaty Creek, and Treaty Creek. Create low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades.	1	6,9	X		
Treaty	-	Treaty Creek	2	Majority off-channel habitat within the Treaty Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Poor quality stream and small relic beaver dams present within the floodplain is limited in productive capacity for summer rearing and overwintering habitat. Relic beaver ponds lack complexity, water depth and fish accessibility. Availability of good spawning habitat to seed off-channel habitat is lacking.	Create overwintering and rearing habitat. Create series of deep ponds with LWD cover and connecting channels to ponds. Create spawning habitat and complexity within channel. Provide fish access to ponds.	Complex design. Intercept exisiting lake-source stream for water supply to construct impermeable berms to backwater a series of deep ponds. Add cabled LWD complexes to ponds. Add SWD and overhanging cover, as required. Connect ponds to each other and Treaty Creek through excavation of channel. Create channel complexity through the addition of LWD structures, gravel placement and gravel retention structures. Incorporate channels to allow fish access around/through ponds.	1	6,9	X		
Treaty	-	Treaty Creek	3	Majority off-channel habitat within the Treaty Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Good quality beaver pond present within the floodplain with lake-source stream for water supply. Beaver ponds limited in productive capacity for summer rearing and overwintering habitat because of fish in-accessibility to Treaty Creek.	Improve fish passage past beaver dams to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Install beaver dam bypass channels to allow fish movement. Improve fish cover by adding cabled LWD complexes to ponds. Re-enforce beaver dams by berming dam materials.	1	9,6	X		
Treaty	Gilbert	Gilbert Creek	1	Fish inaccessibility upstream of large beaver dam. Good quality rearing, overwintering and spawning habitat downstream of beaver dam. Fair quality rearing habitat, poor quality overwintering and spawning habitat upsteam of beaver dam. Lack of pool habitat, embedded gravel substrates, and low frequency of functional LWD frequency. Gilbert Creek prone to flood risk from glacial tributary.	Improve fish passage past beaver dam to enable adult migration to upstream reaches and seed under-utlized rearing habitat. Addition of functional LWD within the channel to improve the diversity of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting.	Breach dams, beaver fencing, riparian management. Create channel complexity through the addition of anchored LWD complexes. Construct berm between Gilbert Creek and glacial tributary to protect high value creek.	3,4,9	6		X	

Dashes indicate not applicable

(continued)

Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Treaty	Gilbert	Gilbert Creek	2	Fish inaccessibility upstream of large beaver dam. Abundant, high value littoral zone rearing habitat within Gilbert Lake. Lack of suitable and sufficient spawning habitat to seed lake littoral zone with Coho salmon parr.	Create groundwater spawning and fry rearing channel to seed under-utilized lake littoral parr rearing habitat. Addition of functional LWD to add channel complexity.	Excavate groundwater channel from West Todedada Creek fan towards Gilbert Lake mouth. Create channel complexity through addition of anchored LWD complexes, gravel placement, and gravel retention structures.	7	2,9	X		
Treaty	Todedada	East Todedada Creek	1	Upper reach of East Todedada Creek lacks cover for rearing fry and parr, no functional LWD, composed of a high proportion of riffle-run habitats with low pool frequency for overwintering. Good spawning habitat is localized. Majority of gravels are embedded and and spawning habitat is underutilized throughout the upper reach.	Improve mainstem rearing, overwintering and spawning habitat. Addition of functional LWD within the mainstem to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting.	Create channel complexity through the addition of anchored LWD complexes at suitable locations. Add anchored LWD to existing barren pools to enhance overwintering and rearing habitat.	4	5		X	
Treaty	Todedada	East Todedada Creek	2	Off-channel wetland habitat lacks overwintering habitat cover. Existing beaver dams restrict adult fish passage, smolt emigration, and fish movement.	Improve overwintering habitat cover with LWD.	Improve fish cover by adding cabled LWD complexes to wetlands.	1	-	X		
Treaty	Todedada	East Todedada Creek	3	Lower reach of East Todedada Creek lacks depth and velocity characteristics for summer rearing fish. Slough, backwater glide habitat created by small check beaver dams. LWD and cover for rearing fish absent.	Improve velocity and depth profile for summer rearing fish in select locations by increasing channel complexity. Add LWD complexes within glide habitat to add cover for summer rearing fish.	Remove a selection of small beaver check dams and replacing with anchored LWD and boulders covering a proportion of the stream cross-sectional area. Create deeper backwater areas to generate elevational drop and ideal velocity and depth profile. Add anchored LWD to glide habitat.	4	-		X	
Treaty	Todedada	Todedada Creek	1	Middle to upper reaches of Todedada Creek lack good rearing habitat, no functional LWD, composed of a high proportion of riffle-run habitats, high velocity flows during summer rearing, low pool frequency with no cover. Abundant spawning gravels are present, however spawning habitat is underutilized.	Improve mainstem rearing, overwintering and spawning habitat. Addition of functional LWD within the mainstem to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting. Add boulder clusters for cover in proper hydraulic sites.	Create channel complexity through the addition of anchored LWD complexes at suitable locations. Add anchored LWD to existing barren pools to enhance overwintering and rearing habitat. Add boulder clusters of proper size and location.	4	5		X	
Treaty	Todedada	Todedada Creek	2	Middle reach of Todedada Creek lack good spawning habitat, no functional LWD, composed of a high proportion of riffle-run habitats, high velocity flows during summer rearing, low pool frequency with no cover. Tribuatry of Todedada Creek provides good overwintering habitat that is underutilized.	Create new off-channel spawning and rearing habitat in a blind groundwater channel along West Todedada Creek fan. Add LWD and spawning substrate. Create pools, riffles and alcove ponds. Direct channel towards existing overwintering habitat along valley floor.	Excavate groundwater channel along fan and complex with LWD, gravel, and gravel retention structures.	1	2,9	X		
Bell-Irving	Glacier	Glacier Creek	1	Lower reach of Glacier Creek, downstream of culvert, is dominated by cascade habitats, lacks suitable rearing habitat for juvenile fish, with poor quality spawning and overwintering habitat. High channel gradient and high velocity unsuitable for fry and parr rearing, and adult spawning.	Create low gradient side channel to provide rearing and overwintering habitat, with spawning habitat benefits. Add LWD and boulders to create a channel complexity and cover.	Complex design. Construct water intake control structure at entry of side-channel. Excavate side-channel. Create chanel complexity by adding anchored LWD complexes and boulders. Provide low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades.	2	9	X		
Bell-Irving	Taft	Taft Creek	1	Lower reach of Taft Creek, downstream of brudge, is dominated by cascade habitats, lacks suitable rearing habitat for juvenile fish, with poor quality spawning habitat. High channel gradient and high velocity mainstem unsuitable for fry and parr rearing, and adult spawning.	Create low gradient side channel with alcove ponds to provide rearing, spawning habitat, with overwintering habitat benefits. Add LWD and boulders to create a channel complexity and cover.	Complex design. Construct water intake control structure at entry of side-channel. Excavate side-channel. Create chanel complexity by adding anchored LWD complexes and boulders. Provide low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades. Excavate alcove ponds.	2	9	X		

Dashes indicate not applicable

(continued)

Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Bell-Irving	Taft	Taft Creek	2	Off-channel habitat within lower reach of Taft Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Good quality off-channel habitat is inaccessible to fish limiting the productive capacity for summer rearing and overwintering.	Improve fish passage past beaver dam to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Complex design. Construct water intake control structure at entry of off-channel. Excavate side-channel. Create chanel complexity by adding anchored LWD complexes and boulders. Provide low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades. Improve fish cover by adding cabled LWD complexes to ponds.	1	9,6	X		
Bell-Irving	-	Bell-Irving River	1	Functional off-channel pond habitat adjacent to the Bell-Irving River is in limited supply. Groundwater source off-channel pond at site has shallow water depth and beaver dam restricts fish passage.	Improve poor quality overwintering habitat by increasing water depth. Allow for juvenile fish passage. Add LWD complexes to pond to create summer rearing and overwintering cover. Increase productive capacity of groundwater pond	Create berm to backup water and increase depth of pond. Install beaver dam bypass channel to allow fish movement. Improve fish cover by adding cabled LWD complexes to pond.	1	6	X		
Bell-Irving	Oweegee	Oweegee Creek	1	Lower reach of Oweegee Creek lacks good rearing habitat and spawning habitat, low frequency of functional LWD, composed of a high proportion of riffle-run habitats, and low pool frequency.	Improve mainstem rearing, overwintering and spawning habitat. Addition of functional LWD within the mainstem to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting. Add boulder clusters for cover in proper hydraulic sites.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	4	-		X	
Bell-Irving	Oweegee	Oweegee Creek	2	Side-channel fed by Oweegee Creek baseflow with seasonal influence from Bell-Irving River mainstem. Channel provides low abundance of spawning habitat, provides poor rearing habitat in low velocity glide habitat with no cover, and provides low abundance of overwintering habitat.	Increase the abundance and quality of spawning habitat. Addition of functional LWD within the side-channel to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting.	Construct water control structure at entry of side-channel with Bell-Irving River. Create chanel complexity by adding anchored LWD complexes, boulders and constricting channel width. Create channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover.	3	2,1	X		
Bell-Irving	Mere	Mere Creek	1	Mere Creek lacks pools for overwintering and abundant gravel for spawning.	Improve poor quality overwintering habitat and poor quality spawning habitat.	Create pools by backwatering with rock riffles or using lateral wood structures to scour riffles/glides into pools; add wood debris and coarse substrate for cover. Add gravel and/or gravel rentention structures to improve abundance and quality of spawning area.	4	7		X	
Bowser	-	Bowser River	1	Off-channel habitat within Bowser River Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Good quality off-channel habitat is inaccessible to fish limiting the productive capacity for summer rearing and overwintering.	Improve fish passage past beaver dam to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Install beaver dam bypass channel to allow fish movement. Improve fish cover by adding cabled LWD complexes to ponds. Re-enforce beaver dams by berming dam materials.	1	6,9	X		
Bowser	-	Bowser River	2	Off-channel habitat within Bowser River Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Good quality off-channel habitat is inaccessible to fish limiting the productive capacity for summer rearing and overwintering.	Improve fish passage past beaver dam to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Install beaver dam bypass channel to allow fish movement. Improve fish cover by adding cabled LWD complexes to ponds. Re-enforce beaver dams by berming dam materials.	1	6,9	X		

Dashes indicate not applicable

(continued)

Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites (completed)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Bowser	-	Bowser River	3	Lower reach of Unnamed Creek, downstream of beaver pond complex, lacks good summer rearing habitat and spawning habitat, low frequency of functional LWD, composed of a high proportion of riffle-run habitats, and low pool frequency.	Improve mainstem rearing and spawning habitat. Addition of functional LWD within the mainstem to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	4	-		X	
Bell-Irving	-	Bell-Irving River	1	Bell-Irving River side channels provide seasonal rearing habitat during moderate/high flows, but are generally not active during the fall through spring. The side channels lack deep overwintering pools in association with LWD.	Enhance or create deep scour pools and associated LWD structures to provide overwintering pools and improved rearing habitat complexity at high flows.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	2	-	X		
Bell-Irving	-	Bell-Irving River	2	Bell-Irving River side channels provide seasonal rearing habitat during moderate/high flows, but are generally not active during the fall through spring. The side channels lack deep overwintering pools in association with LWD. Clear tributary discharges into side channel provide realiable water source.	Enhance or create deep scour pools and associated LWD structures to provide overwintering pools and improved rearing habitat complexity at high flows.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	2	-	X		
Bell-Irving	-	Bell-Irving River	3	Bell-Irving River side channels provide seasonal rearing habitat during moderate/high flows, but are generally not active during the fall through spring. The side channels lack deep overwintering pools in association with LWD. Overwintering channel lacks functional LWD.	Enhance or create deep scour pools and associated LWD structures to provide overwintering pools and improved rearing habitat complexity at high flows.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	2	-	X		
Bell-Irving	-	Bell-Irving River	4	Bell-Irving River side-channels provide seasonal rearing during moderate and high flows but generally cease flowing in the fall through spring. The side-channels generally lack deep overwintering pools in association with woody debris. Lower 250 m of channel provides overwintering habitat, but lacks LWD cover.	Enhance or create deep scour pools and associated LWD structures to provide overwintering pools and improved rearing habitat complexity at high flows.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	2	-	X		

Dashes indicate not applicable

Figure 6.2-2

SEABRIDGE GOLD
KSM PROJECT

Location of Compensation Projects - Map 2

Figure 6.2-2

Rescan
Engineers & Scientists

A summary of fish species and life history stages present at each preliminary project is presented in Table 6.2-2. Dolly Varden and coho salmon were the most common species present at the majority of compensation sites. The abundance and distribution of fish at specific preliminary compensation sites varied depending on habitat limitations. Target habitat and species priorities were assigned to each preliminary compensation site based upon field assessment data and compensation concept techniques (Table 6.2-3). Target species-specific life history stages were identified for each preliminary compensation site.

Table 6.2-4 summarizes the existing physical environment conditions for each compensation site. Primary and secondary water sources (e.g., surface or ground water) are identified, including their magnitude and dependability. Potential concerns from flood risk, water and sediment quality, and obstructions were identified.

6.2.2 Project Screening

Each preliminary compensation project was screened according to a set of high level criteria (Table 6.2-5). These criteria included: DFO hierarchy for compensation, regional fisheries management objectives, inclusion of traditional knowledge, technical feasibility, economic feasibility, stability and permanence, and biological relevance.

DFO hierarchy for compensation was classified for each compensation site. The classifications are:

1. replacing lost habitat with the same habitat in the same ecological unit;
2. increasing the productive capacity of existing habitat with unlike habitat in the same ecological unit;
3. (a) replacing lost habitat with like-for-like habitat in another ecological unit;
   (b) replacing lost habitat with like-for-unlike habitat in another ecological unit; and
4. using artificial production (i.e., building hatcheries or fertilizing lakes).

Regional fish and fish habitat objectives specifically relevant to fish and aquatic habitat study area watersheds have not been developed by the BC MOE. The BC MOE has developed provincial fisheries management objectives for species other than migratory Pacific salmon (BC MOE 2010b), which were applied for the screening. These objectives broadly include:

- maintaining healthy fish habitat;
- maintaining or enhancing indigenous fish populations;
- sustaining water quality and use;
- effective management and stewardship of fish and wildlife species, ecosystems, and protected areas;
- shared stewardship with Aboriginal groups to protect the environment; and
- increasing and diversifying angling opportunities for recreation and employment.

Similarly DFO has not developed specific regional objectives for the study area watersheds. However, DFO is responsible for the management of migratory Pacific salmon; therefore, this was taken into consideration during the screening. In general, DFO habitat managers strive (pursuant to the *No Net Loss* guiding principle) to maintain the current productive capacity of fish habitat. This supports Canada's fishery resources, such that the habitat is able to produce fish suitable for human consumption (DFO 1998). In order to satisfy the *No Net Loss* guiding principle, the habitat manager's first priority is to avoid or reduce the project's potential for a habitat impact through appropriate mitigation measures.

Table 6.2-2. Species and Life History Stages Present at Compensation Sites

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Species and Life Stage Present																				
					Dolly Varden			Bull Trout			Rainbow Trout / Steelhead			Coho Salmon				Chinook Salmon			Sockeye Salmon			Mountain Whitefish		
					Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr (1+)	Parr (2+)	Adult	Fry	Parr (1+)	Adult	Fry	Parr	Adult	Fry	Parr	Adult
Treaty	-	Treaty Creek	1	Off-channel pond creation			X						X												
Treaty	-	Treaty Creek	3	Off-channel pond fish passage enhancement	X	X	X																		
Treaty	-	Treaty Creek	2	Off-channel pond creation	X	X	X																		
Teigen	-	Teigen Creek	4	Off-channel pond fish passage enhancement										X	X	X		X							
Teigen	-	Teigen Creek	1	Off-channel pond creation and fish passage enhancement	X	X	X					X		X	X	X									
Treaty	Todedada	East Todedada Creek	2	Off-channel pond fish passage enhancement		X	X							X	X	X									
Bell-Irving	Glacier	Glacier Creek	1	Side channel habitat creation	0	X	X						X	X			X								
Bell-Irving	Taft	Taft Creek	1	Off-channel pond complex	X	X	X	X	X	X	X	X	X	X	0		X	X		X				X	X	X
Bell-Irving	Taft	Taft Creek	2	Off-channel pond complex and fish passage enhancement			X							X	X										
Bell-Irving	-	Bell-Irving River	1	Off-channel pond creation and fish passage enhancement			X								X	X									
Bowser	-	Bowser River	1	Off-channel pond fish passage enhancement																					
Bowser	-	Bowser River	2	Off-channel pond fish passage enhancement			X							X											
Teigen	-	Teigen Lake	3	Littoral zone LWD enhancement	0	0	X	0	0	X	0	0	X					0		X				0	0	X
Teigen	Hodkin	Hodkin Lake	1	Littoral zone LWD enhancement	X	X	X																		
Unuk	-	Unuk Lake	1	Littoral zone LWD enhancement	X	X	X																		
Treaty	Gilbert	Gilbert Lake	1	Littoral zone LWD enhancement	0	0	X	0	0	X	0	0	X											0	0	X
Teigen	Hodkin	Hodkin Lake Creek 1	2	Stream spawning habitat creation	X	X	X																		
Teigen	Hodkin	Hodkin Lake Creek 2	3	Stream spawning habitat creation	X	X	X																		
Bowser	-	Bowser River	3	Mainstem LWD and pool enhancement	X	X	X				X	X	0	X			x								
Teigen	-	Teigen Creek	3	Mainstem pool habitat creation	X	X	X	X	X	X	X	X	X	X	X	0	X	X	0	X	0		X	X	X	X
Teigen	South Teigen	South Teigen Creek	1	Mainstem pool habitat creation	X	X	X	X	X	X		X												0	X	X
Teigen	Snowbank	Snowbank Creek	1	Mainstem pool habitat creation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X				0	X	X
Teigen	-	Teigen Creek	2	Side channel habitat enhancement and creation	X	X	X				0	X		X	0		X	X		X						
Treaty	Gilbert	Gilbert Creek	1	Mainstem pool habitat creation and fish passage enhancement	Z	Z	Z				X	X	x	Y	Y		Y	Y		Y				Z	Z	Z
Treaty	Todedada	East Todedada Creek	1	Mainstem LWD and pool enhancement	X	X	X							X	0		X									
Treaty	Todedada	East Todedada Creek	3	Mainstem LWD and pool enhancement	X	X	X							X	0		X				Y	Y				
Treaty	Todedada	Todedada Creek	1	Mainstem LWD, boulder and pool enhancement	X	X	X		X	0			0	X	0	0	X	0	X	0	0	X		0	0	X
Bell-Irving	Oweegee	Oweegee Creek	1	Mainstem LWD and pool enhancement	X	X	X	0	0	X	X	X	0	X	X	0	X	0		X	0	X		0	X	X
Bell-Irving	Oweegee	Oweegee Creek	2	Side channel LWD and pool enhancement						X	X	0	0	X	0	0	X	X		X	0	X		0	0	0
Bell-Irving	Mere	Mere Creek	1	Mainstem pool habitat creation	X	X	X				X	0	0	X	X		X									
Bell-Irving	-	Bell-Irving River	1	Side channel LWD and pool enhancement										X	X			X						X	X	
Bell-Irving	-	Bell-Irving River	2	Side channel LWD and pool enhancement								X		X	X			X	X							
Bell-Irving	-	Bell-Irving River	3	Side channel LWD and pool enhancement										X				X						X	X	
Bell-Irving	-	Bell-Irving River	4	Side channel LWD and pool enhancement								X						X						X		

Dashes indicate not applicable

X' indicates species and life history stage confirmed present through fieldwork or FDIS data

O' indicates species life history stage assumed to be present given site-specific habitat

Y' indicates species only present downstream of 1st beaver dam

Z' indicates species only present downstream of 1st beaver dam and within lake

Table 6.2-3. Target Habitat, Species, and Life History Stage Priorities for Compensation Sites

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Target Habitat Priorities				Target Species Priorities						Target Species and Life Stage																	
															Dolly Varden			Bull Trout			Rainbow Trout / Steelhead			Coho Salmon			Chinook Salmon			Sockeye Salmon		
					Spawning	Rearing	Overwintering	Migration	Dolly Varden	Bull Trout	Rainbow Trout / Steelhead	Coho Salmon	Chinook Salmon	Sockeye Salmon	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult
Teigen	-	Teigen Lake	1	Littoral zone LWD enhancement		1			2	1	3				X	X		X	X		X	X										
Teigen	Hodkin	Hodkin Lake	1	Littoral zone LWD enhancement		1			1						X	X																
Unuk	-	Unuk Lake	1	Littoral zone LWD enhancement		1			1						X	X																
Treaty	Gilbert	Gilbert Lake	1	Littoral zone LWD enhancement		1			2	3	4	1			X	X		X	X		X	X		X	X							
Teigen	Hodkin	Hodkin Lake Creek 1	2	Stream spawning habitat creation	1	2			1						X		X															
Teigen	Hodkin	Hodkin Lake Creek 2	3	Stream spawning habitat creation	1	2			1						X		X															
Teigen	-	Teigen Creek	3	Mainstem pool habitat creation	3	2	1			3	2		1					X	X	X	X	X	X				X	X	X			
Teigen	South Teigen	South Teigen Creek	1	Mainstem pool habitat creation	3	2	1		1	2					X	X	X	X	X	X												
Teigen	Snowbank	Snowbank Creek	1	Mainstem pool habitat creation	3	2	1		5	3	2	4	1		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Teigen	-	Teigen Creek	1	Off-channel pond creation and fish passage enhancement	4	2	1	3	2		3	1			X	X	X				X	X		X	X	X						
Teigen	-	Teigen Creek	2	Side channel habitat enhancement and creation	4	2	1	3	2	3	4	1	5		X	X	X	X	X	X	X	X		X	X	X	X		X				
Teigen	-	Teigen Creek	4	Off-channel pond fish passage enhancement		3	1	2	2			1			X	X	X							X	X							
Treaty	-	Treaty Creek	1	Off-channel pond	4	2	1	3	1		3	2			X	X	X				X	X		X	X	X						
Treaty	-	Treaty Creek	2	Off-channel pond creation	4	2	1	3	2		3	1			X	X	X				X	X		X	X	X						
Treaty	-	Treaty Creek	3	Off-channel pond fish passage enhancement		2	1	3	2		3	1			X	X	X				X	X		X	X							
Treaty	Gilbert	Gilbert Creek	1	Mainstem pool habitat creation and fish passage enhancement	4	3	2	1	4	3	2	1	5		X	X	X	X	X	X	X	X	X	X	X	X	X		X			
Treaty	Gilbert	Gilbert Creek	2	Groundwater spawning channel creation	1	2				3	2	1						X		X	X		X	X		X						
Treaty	Todedada	East Todedada Creek	1	Mainstem LWD and pool enhancement	3	2	1		2			1			X	X	X							X	X	X						
Treaty	Todedada	East Todedada Creek	2	Off-channel pond enhancement		3	2		2			1			X	X	X							X	X	X						
Treaty	Todedada	East Todedada Creek	3	Mainstem LWD and pool enhancement	3	1	2		2			1		3	X	X	X							X	X	X				X		X
Treaty	Todedada	Todedada Creek	1	Mainstem LWD, boulder and pool enhancement	3	2	1		3	4		2	1		X	X	X	X	X	X				X	X	X	X		X			
Treaty	Todedada	Todedada Creek	2	Groundwater spawning channel creation	1	2	3		2	3		1	4		X	X	X	X	X	X				X		X	X		X			
Bell-Irving	Glacier	Glacier Creek	1	Side channel habitat creation	3	1	2		1		2	3			X	X	X				X	X	X	X	X	X						
Bell-Irving	Taft	Taft Creek	1	Side channel and alcove pond habitat creation	4	2	1	3	2	4		1	3					X	X	X	X	X	X	X	X	X	X		X			
Bell-Irving	Taft	Taft Creek	2	Off-channel pond fish passage enhancement	4	2	1	3	2			1			X	X	X							X	X							

Dashes indicate not applicable

(continued)

Table 6.2-3. Target Habitat, Species, and Life History Stage Priorities for Compensation Sites (completed)

					Target Habitat Priorities				Target Species Priorities						Target Species and Life Stage														
															Dolly Varden			Bull Trout			Rainbow Trout / Steelhead			Coho Salmon			Chinook Salmon			Sockeye Salmon		
Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Spawning	Rearing	Overwintering	Migration	Dolly Varden	Bull Trout	Rainbow Trout / Steelhead	Coho Salmon	Chinook Salmon	Sockeye Salmon	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult
Bell-Irving	-	Bell-Irving River	1	Off-channel pond creation and fish passage enhancement		3	2	1	2			1			X	X	X							X	X							
Bell-Irving	Oweegee	Oweegee Creek	1	Mainstem LWD and pool enhancement	3	2	1			3	1	2						X	X	X	X	X	X	X	X	X						
Bell-Irving	Oweegee	Oweegee Creek	2	Side channel LWD and pool enhancement	1	2	3			5	4	3	1	2					X	X	X	X		X	X		X			X		X
Bell-Irving	Mere	Mere Creek	1	Mainstem pool habitat creation	3	2	1		2		3	1			X	X	X				X	X		X	X	X						
Bowser	-	Bowser River	1	Off-channel pond fish passage enhancement		3	2	1	2		3	1			X	X	X					X	X	X	X							
Bowser	-	Bowser River	2	Off-channel pond fish passage enhancement		3	2	1	2		3	1			X	X	X					X	X	X	X							
Bowser	-	Bowser River	3	Mainstem LWD and pool enhancement	3	2	1		3		2	1			X	X	X				X	X	X	X	X	X						
Bell-Irving	-	Bell-Irving River	1	Side channel LWD and pool enhancement		2	1					1	2											X	X		X	X				
Bell-Irving	-	Bell-Irving River	2	Side channel LWD and pool enhancement		2	1					1	2											X	X		X	X				
Bell-Irving	-	Bell-Irving River	3	Side channel LWD and pool enhancement		2	1					1	2											X	X		X	X				
Bell-Irving	-	Bell-Irving River	4	Side channel LWD and pool enhancement		2	1					1	2											X	X		X	X				

Dashes indicate not applicable

Table 6.2-4. Existing Physical Environment Conditions for Compensation Sites

Watershed	Sub-Watershed	Waterbody	Watershed Site Number	Compensation Project Type	Physical Environment								
					Primary Watersource	Secondary Watersource	Water Supply Magnitude	Surface Water Supply Dependability	Flood Risk	Water Quality Concerns	Sediment Supply Concerns	Gradient	Obstructions
Teigen	-	Teigen Lake	1	Littoral zone LWD enhancement	SW	-	-	-	-	N	N	-	-
Teigen	Hodkin	Hodkin Lake	1	Littoral zone LWD enhancement	SW	-	-	-	-	N	N	-	-
Unuk	-	Unuk Lake	1	Littoral zone LWD enhancement	SW	-	-	-	-	N	N	-	-
Treaty	Gilbert	Gilbert Lake	1	Littoral zone LWD enhancement	SW	-	-	-	-	N	N	-	-
Teigen	Hodkin	Hodkin Lake Creek 1	2	Stream spawning habitat creation	SW	GW Minor	L	L Low winter flows	L	N	L Low energy stream and low gravel recruitment	L	N
Teigen	Hodkin	Hodkin Lake Creek 2	3	Stream spawning habitat creation	SW	GW Minor	L	L Low winter flows	L	N	L Low energy stream and low gravel recruitment	L	N
Teigen	-	Teigen Creek	3	Mainstem pool habitat creation	SW	-	H	H Lake headwater	M Teigen Creek mainstem	N	N	L/M	N
Teigen	South Teigen	South Teigen Creek	1	Mainstem pool habitat creation	SW	-	M	H	M South Teigen Creek mainstem	N	N	M	N
Teigen	Snowbank	Snowbank Creek	1	Mainstem pool habitat creation	SW	-	H	H Large headwater wetland	M Snowbank Creek mainstem	Y High turbidity	Y High sediment load from Redflat Creek	L/M	N
Teigen	-	Teigen Creek	1	Off-channel pond creation and fish passage enhancement	SW	GW	L	L Low winter flows, Groundwater supply dependable	L	N	N	L	Y Beaver dams
Teigen	-	Teigen Creek	2	Side channel habitat enhancement and creation	SW	GW	M	M Supply determined by mobility of Teigen Creek bed at inlet	M Direct connection to Teigen Creek mainstem	N	N	L	Y Beaver dams
Teigen	-	Teigen Creek	4	Off-channel pond fish passage enhancement	SW	GW	L	H	M Potential for Teigen Creek influence upstream of site	P Possible low winter DO	N	L	Y Beaver dams
Treaty	-	Treaty Creek	1	Off-channel pond creation	GW	SW Minor	L	L Groundwater supply dependable	L	P Possible low winter DO	N	L	Y Beaver dams
Treaty	-	Treaty Creek	2	Off-channel pond creation	SW	GW	L	H Lake headwater	L	P Possible low winter DO	N	L	Y Beaver dams
Treaty	-	Treaty Creek	3	Off-channel pond fish passage enhancement	SW	GW	L	H Lake and wetland headwater	L	P Possible low winter DO	N	L	Y Beaver dams

(continued)

Dashes indicate not applicable
Primary and Secondary Watersource: SW = surface water, GW = groundwater
Water Supply Magnitude: L = Low
Surface Water Supply Dependability: L = Low, M = Moderate, H = High
Flood Risk: L = Low, M = Moderate, H = High
Water Quality Concerns: Y = Yes, N = No, P = Probable
Sediment Supply Concerns: N = None, L = Low, M = Moderate, H = High
Gradient: L = Low (0 - 2%), M = Moderate (3 - 5%), H = High (> 6%)
Obstructions: Y = Yes, N = No
DO = dissolved oxygen

Table 6.2-4. Existing Physical Environment Conditions for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody	Watershed Site Number	Compensation Project Type	Physical Environment								
					Primary Watersource	Secondary Watersource	Water Supply Magnitude	Surface Water Supply Dependability	Flood Risk	Water Quality Concerns	Sediment Supply Concerns	Gradient	Obstructions
Treaty	Gilbert	Gilbert Creek	1	Mainstem pool habitat creation and fish passage enhancement	SW	GW	L	H Lake headwater, High groundwater table	M Flood risk from West Todedada Creek	N	N	L	Y Beaver dams
Treaty	Gilbert	Gilbert Creek	2	Groundwater spawning channel creation	GW	-	L	H	N	N	N	L	N
Treaty	Todedada	East Todedada Creek	1	Mainstem LWD and pool enhancement	SW	GW	L	H Large groundwater source	M Flood risk from Todedada Creek	N	N	L	N
Treaty	Todedada	East Todedada Creek	2	Off-channel pond enhancement	SW	GW	L	H Large groundwater source	N	N	N	L	Y Beaver dams
Treaty	Todedada	East Todedada Creek	3	Mainstem LWD and pool enhancement	SW	GW	L	H Large groundwater source	N	N	N	L	Y Beaver dams
Treaty	Todedada	Todedada Creek	1	Mainstem LWD, boulder and pool enhancement	SW	GW	H	H Large groundwater source	M Todedada Creek mainstem	Y Turbidity	Y High glacial sediment load	L	N
Treaty	Todedada	Todedada Creek	2	Groundwater spawning channel creation	GW	-	L	H	N	N	N	L	N
Bell-Irving	Glacier	Glacier Creek	1	Side channel habitat creation	SW	-	M	M Possible low winter flows	L	N	N	L/M	N
Bell-Irving	Taft	Taft Creek	1	Side channel and alove pond habitat creation	SW	GW Minor	H	H	L	Y Turbidity	Y High glacial sediment load	L	N
Bell-Irving	Taft	Taft Creek	2	Off-channel pond fish passage enhancement	GW	SW Minor	L	L Groundwater supply dependable	L	P Possible low winter DO	N	L	Y Beaver dams
Bell-Irving	-	Bell-Irving River	1	Off-channel pond creation and fish passage enhancement	GW	-	L	L Groundwater supply dependable	L	P Possible low winter DO	N	L	Y Beaver dams
Bell-Irving	Oweegee	Oweegee Creek	1	Mainstem LWD and pool enhancement	SW	GW Minor	L	H Lake headwater	L	N	N	L/M	N
Bell-Irving	Oweegee	Oweegee Creek	2	Side channel LWD and pool enhancement	SW	GW Minor	L-H Depends on influence of Bell-Irving River	H Lake headwater	H	N	Y Glacial sediment load from Bell-Irving River	L	N
Bell-Irving	Mere	Mere Creek	1	Mainstem pool habitat creation	SW	-	L	L Possible low winter flows	L	N	N	L	N

Dashes indicate not applicable

(continued)

Primary and Secondary Watersource: SW = surface water, GW = groundwater
Water Supply Magnitude: L = Low
Surface Water Supply Dependability: L = Low, M = Moderate, H = High
Flood Risk: L = Low, M = Moderate, H = High
Water Quality Concerns: Y = Yes, N = No, P = Probable
Sediment Supply Concerns: N = None, L = Low, M = Moderate, H = High
Gradient: L = Low (0 - 2%), M = Moderate (3 - 5%), H = High (> 6%)
Obstructions: Y = Yes, N = No
DO = dissolved oxygen

Table 6.2-4. Existing Physical Environment Conditions for Compensation Sites (completed)

					Physical Environment								
Watershed	Sub-Watershed	Waterbody	Watershed Site Number	Compensation Project Type	Primary Watersource	Secondary Watersource	Water Supply Magnitude	Surface Water Supply Dependability	Flood Risk	Water Quality Concerns	Sediment Supply Concerns	Gradient	Obstructions
Bowser	-	Bowser River	1	Off-channel pond fish passage enhancement	GW	SW Minor	L	L Low winter flows, Groundwater supply dependable	L	P Possible low winter DO	N	L	Y Beaver dams
Bowser	-	Bowser River	2	Off-channel pond fish passage enhancement	SW	GW	L	H Large beaver pond complex within lake headed system	L	P Possible low winter DO	N	L	Y Beaver dams
Bowser	-	Bowser River	3	Mainstem LWD and pool enhancement	SW	GW	L	H Large beaver pond complex within lake headed system	L	N	N	L	N
Bell-Irving	-	Bell-Irving River	1	Side channel LWD and pool enhancement	SW	-	H	H	H	N	Y Glacial sediment load from Bell-Irving River	L	N
Bell-Irving	-	Bell-Irving River	2	Side channel LWD and pool enhancement	SW	-	H	H	H	N	Y Glacial sediment load from Bell-Irving River	L	N
Bell-Irving	-	Bell-Irving River	3	Side channel LWD and pool enhancement	SW	-	H	H	H	N	Y Glacial sediment load from Bell-Irving River	L	N
Bell-Irving	-	Bell-Irving River	4	Side channel LWD and pool enhancement	SW	-	H	H	H	N	Y Glacial sediment load from Bell-Irving River	L	N

Dashes indicate not applicable
Primary and Secondary Watersource: SW = surface water, GW = groundwater
Water Supply Magnitude: L = Low
Surface Water Supply Dependability: L = Low, M = Moderate, H = High
Flood Risk: L = Low, M = Moderate, H = High
Water Quality Concerns: Y = Yes, N = No, P = Probable
Sediment Supply Concerns: N = None, L = Low, M = Moderate, H = High
Gradient: L = Low (0 - 2%), M = Moderate (3 - 5%), H = High (> 6%)
Obstructions: Y = Yes, N = No
DO = dissolved oxygen

Table 6.2-5. Screening Criteria for Compensation Sites

Watershed	Sub-Watershed	Waterbody (s)	Site Number	Compensation Project Type	Screening Criteria						
					DFO Hierarchy for Compensation	Regional Fisheries Management Objectives	Inclusion of TK and TLU	Technically Feasible	Economically Feasible	Stable and Permanent	Biologically Relevant
Teigen	-	Teigen Lake	1	Littoral zone LWD enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses MOE objectives	Pending Site immediately outside of KSM fisheries study area boundary but within Teigen Creek Watershed, Discussed at working group meetings	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	Hodkin	Hodkin Lake	1	Littoral zone LWD enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit	Yes Dolly Varden specific benefit
Unuk	-	Unuk Lake	1	Littoral zone LWD enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden specific benefit
Treaty	Gilbert	Gilbert Lake	1	Littoral zone LWD enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	Hodkin	Hodkin Lake Creek 1	2	Stream spawning habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden specific benefit, Increased productive capacity of Hodkin Lake
Teigen	Hodkin	Hodkin Lake Creek 2	3	Stream spawning habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden specific benefit, Increased productive capacity of Hodkin Lake
Teigen	-	Teigen Creek	3	Mainstem pool habitat creation	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	South Teigen	South Teigen Creek	1	Mainstem pool habitat creation	1 Increase productive capacity of like-for-like habitat in same EU	Adresses MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	Snowbank	Snowbank Creek	1	Mainstem pool habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	-	Teigen Creek	1	Off-channel pond creation and fish passage enhancement	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Teigen	-	Teigen Creek	2	Side channel habitat enhancement and creation	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	-	Teigen Creek	4	Off-channel pond fish passage enhancement	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Treaty	-	Treaty Creek	1	Off-channel pond creation	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Treaty	-	Treaty Creek	2	Off-channel pond creation	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit

Dashes indicate not applicable

(continued)

EU = ecological unit

TK = traditional knowledge

TLU = traditional land use

DFO Hierarchy for Compensation = refer to Section 6.2.2 for definitions

Table 6.2-5. Screening Criteria for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody (s)	Site Number	Compensation Project Type	Screening Criteria						
					DFO Hierarchy for Compensation	Regional Fisheries Management Objectives	Inclusion of TK and TLU	Technically Feasible	Economically Feasible	Stable and Permanent	Biologically Relevant
Treaty	-	Treaty Creek	3	Off-channel pond fish passage enhancement	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Treaty	Gilbert	Gilbert Creek	1	Mainstem pool habitat creation and fish passage enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Requires active beaver management	Yes Increased productive capacity of Gilbert Lake, Dolly Varden and multispecies benefit
Treaty	Gilbert	Gilbert Creek	2	Groundwater spawning channel creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	East Todedada Creek	1	Mainstem LWD and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	East Todedada Creek	2	Off-channel pond enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	East Todedada Creek	3	Mainstem LWD and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	Todedada Creek	1	Mainstem LWD, boulder and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	Todedada Creek	2	Groundwater spawning channel creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Bell-Irving	Glacier	Glacier Creek	1	Side channel habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Bell-Irving	Taft	Taft Creek	1	Side channel and alcove pond habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Pending Site outside of KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Bell-Irving	Taft	Taft Creek	2	Off-channel pond fish passage enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Pending Site outside of KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Bell-Irving	-	Bell-Irving River	1	Off-channel pond creation and fish passage enhancement	3b Increase productive capacity of like-for-unlike habitat in a different EU	Adresses DFO and MOE objectives	Pending Site outside of KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Bell-Irving	Oweegee	Oweegee Creek	1	Mainstem LWD and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Bell-Irving	Oweegee	Oweegee Creek	2	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit

Dashes indicate not applicable

(continued)

EU = ecological unit

TK = traditional knowledge

TLU = traditional land use

DFO Hierarchy for Compensation = refer to Section 6.2.2 for definitions

Table 6.2-5. Screening Criteria for Compensation Sites (completed)

					Screening Criteria						
Watershed	Sub-Watershed	Waterbody (s)	Site Number	Compensation Project Type	DFO Hierarchy for Compensation	Regional Fisheries Management Objectives	Inclusion of TK and TLU	Technically Feasible	Economically Feasible	Stable and Permanent	Biologically Relevant
Bell-Irving	Mere	Mere Creek	1	Mainstem pool habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Pending Site outside of KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Bowser	-	Bowser River	1	Off-channel pond fish passage enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Bowser	-	Bowser River	2	Off-channel pond fish passage enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Bowser	-	Bowser River	3	Mainstem LWD and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Bell-Irving	-	Bell-Irving River	1	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit, Large river habitat targeted
Bell-Irving	-	Bell-Irving River	2	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit, Large river habitat targeted
Bell-Irving	-	Bell-Irving River	3	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit, Large river habitat targeted
Bell-Irving	-	Bell-Irving River	4	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit, Large river habitat targeted

Dashes indicate not applicable
EU = ecological unit
TK = traditional knowledge
TLU = traditional land use
DFO Hierarchy for Compensation = refer to Section 6.2.2 for definitions

All preliminary compensation projects fulfilled DFO's and BC MOE's regional fisheries management objectives. The majority of projects included traditional knowledge and traditional land use information, as was made available during Fisheries Working Group meetings, and traditional knowledge and traditional land use reports prepared for the KSM Project. Certain compensation sites lack traditional knowledge and traditional land use information, because the compensation sites are outside of the fish and aquatics study area boundaries. Future Working Group meetings will incorporate traditional knowledge where possible. All projects are economically feasible, stable, and permanent. The majority of projects have the potential for multispecies benefit.

A holistic approach was implemented to prioritize the preliminary compensation sites, with the primary objective of achieving DFO's *No Net Loss* principle and a compensation ratio of approximately 2:1. First, projects that were higher on DFO's hierarchy for compensation were identified. DFO's first preference is projects that replace lost habitat with the same habitat in the same ecological unit. Eights project lie within this category (Table 6.2-5):

- South Teigen Creek Site 1 - mainstem pool habitat creation;
- Teigen Creek Site 1 - off-channel pond creation and fish passage enhancement;
- Teigen Creek Site 2 - side channel habitat enhancement and creation;
- Teigen Creek Site 3 - mainstem pool habitat creation;
- Teigen Creek Site 4 - off-channel pond fish passage enhancement;
- Treaty Creek Site 1 - off-channel pond creation;
- Treaty Creek Site 2 - off-channel pond creation; and
- Treaty Creek Site 3 - off-channel pond fish passage enhancement.

The approach to select the primary projects for detailed analysis considered the screening results, site-specific risks and opportunities, fish habitat area, and HUs gained from preliminary compensation sites, site access, design complexity, and construction costs.

Teigen and South Teigen creeks mainstem pool habitat creation projects are viable projects; however, the application of this pool creation technique is limited to a select few locations, and the overall biological benefit to fish populations within these watersheds would be minimal. Therefore, Teigen Creek Site 3 and South Teigen Site 1 were placed as lower priority.

The remaining projects are off-channel or side channel habitat creation/enhancement projects. Teigen Creek Sites 2 and 4 provide a moderate to high biological benefit to fish populations within these watersheds; however, the site-specific engineering risks due to flooding and erosion are high and would require considerable design complexity. Furthermore, there is no current flowing to proposed site access. Therefore, Teigen Creek Sites 2 and 4 were placed as lower priority.

Treaty Creek Sites 2 and 3 provide a moderate to high biological benefit to fish populations within these watersheds; however, the site-specific engineering risks due to flooding and erosion from Treaty Creek are high and would require considerable design complexity. A protected surface water intake for these projects would be difficult given the geomorphology of Treaty Creek. Therefore, Treaty Creek sites 2 and 3 were placed as lower priority.

Teigen Creek Site 1 and Treaty Creek Site 1 provide a high biological benefit to fish populations within these watersheds. The site-specific engineering risks due to flooding and erosion from the mainstems

are low given the projects' placement within the watershed. A protected surface water intake for these projects is less complex than the other proposed off-channel projects. Furthermore, the proposed Treaty Creek Access Road will be immediately adjacent to Treaty Creek Site 1 and Teigen Creek Site 1 would require a spur access trail from the plant site. Therefore, Teigen Creek Site 1 and Treaty Creek Site 1 were selected to develop *technically feasible compensation designs*. However, additional projects are required for HU budgeting and to achieve a compensation ratio of 2:1 for both the MMER and HADD fish habitat compensation plans.

Following the same logic as discussed above, projects that were next on DFO's hierarchy for compensation were identified. DFO's second preference is projects increasing the productive capacity of existing habitat with unlike habitat in the same ecological unit. However, none of the proposed projects achieved DFO's second preference. DFO's third preference (i.e., 3a) is replacing lost habitat with like-for-like habitat in another ecological unit. Nineteen projects lie within this category (Table 6.2-5).

Mainstem pool habitat creation projects are viable projects; however, the application of this technique is limited to a select few locations and the overall biological benefit to fish populations and productive capacity within these watersheds. Also, some of these mainstem complexing sites are remote and difficult to access (e.g., Hodkin Creek and East Todedada Creek). Therefore, mainstem complexing projects were placed as lower priority.

The remaining projects are variations of off-channel creation with moderate to high biological benefit to fish populations within these watersheds. Of all these projects, Taft Creek Site 1 and Glacier Creek Site 1 were selected to develop *technically feasible compensation designs*. The site-specific engineering risks due to flooding and erosion from the mainstems are low given the projects placement within the watershed. A protected surface water intake for these projects is less complex than the other proposed off-channel projects. Furthermore, access to these projects currently exists along Highway 37.

Of the four priority projects identified above, the following compensation projects were selected based upon the holistic approach and represent *technically feasible compensation sites* for HU budgeting to achieve a compensation ratio of 2:1.

- Treaty Creek Site 1 – Off-channel pond complex habitat creation; and
- Taft Creek Site 1 – Off-channel pond complex habitat creation.

6.3 TECHNICALLY FEASIBLE COMPENSATION PROJECT DESCRIPTIONS

6.3.1 Treaty Creek – Site 1

6.3.1.1 Site Description

Location

Treaty Creek - Site 1 is located at the junction of North Treaty and Treaty creeks (Figure 6.2-1). It is approximately 8 km southeast of the TMF and approximately 20 km upstream of the confluence of Treaty Creek and the Bell-Irving River (Figure 6.2-1). The centre of the proposed project is at Universal Transverse Mercator (UTM) 9U.448000 E, 6270800 N. The nearest road to the site is Highway 37, approximately 22 km east but once the TMF is built, the Treaty Creek Access Road will be immediately adjacent to Site 1.

This site is 2 km long and approximately 500 m wide (Figure 6.3-1; Plates 6.3-1 and 6.3-2). The site includes the large alluvial fan at the mouth of North Treaty Creek and the flat floodplain of Treaty Creek east of the fan. The alluvial fan of North Treaty Creek drops approximately 30 m in elevation within the Site 1 area. North Treaty and Treaty creeks border the north and west sides of the site, respectively.

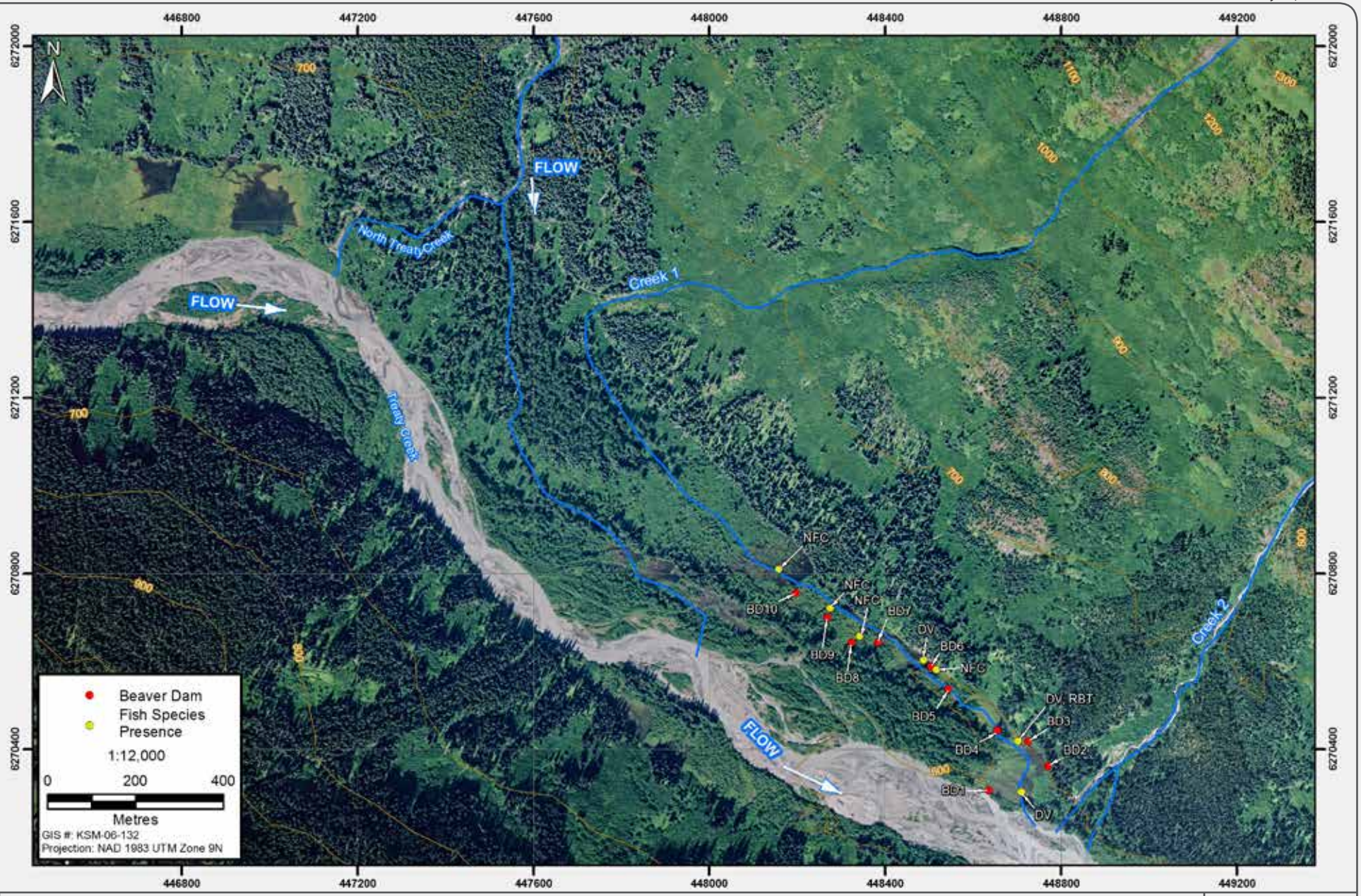

Figure 6.3-1

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Treaty Creek Site 1 - Existing Conditions

Figure 6.3-1

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Plate 6.3-1. Aerial view of Treaty Creek – Site 1.

Plate 6.3-2. Middle section of Treaty Creek – Site 1 with Treaty Creek at top right. Creek 1 on left drains into coniferous trees from the hillslope.

A seasonal watercourse called Creek 1 drains from the northeast mountain slope (Plate 6.3-2) onto the floodplain and through a series of beaver ponds (Figure 6.3-1; Plates 6.3-1 to 6.3-6). Hillslope run-off

flows into the beaver pond complex during spring and summer snowmelt. Another seasonal watercourse called Creek 2 drains the steep hill at the east end of Site 1 into Treaty Creek (Figure 6.3-1). Creek 2 contributes seasonal runoff to the downstream beaver ponds (Plate 6.3-3; left corner of photo). The wide braided channel of Treaty Creek is active and adjacent to Site 1 with numerous flood channels, eroding banks, and beaver dams along the floodplain (Plates 6.3-1 and 6.3-2).

Plate 6.3-3. Downstream section of Site 1 at confluence with Treaty Creek on left.

Creek 1 flows through the site (Figure 6.3-1). A portion of North Treaty Creek flow also braids into the site. Creek 1 has a gradient between 2 and 4% along the east side of the North Treaty Creek alluvial fan, but is less than 1% on the valley bottom. Key details of the aquatic features at the site include:

- ten beaver dams along Creek 1, which range from 0.4 to 1.5 m in height;
- beaver dams were in poor condition, breached or dry (Plates 6.3-3 to 6.3-6);
- eight small beaver ponds (80 to 1,500 m^2) provided 4,345 m^2 of aquatic habitat;
- aquatic habitat quality was poor (less than 50 cm deep) with aquatic vegetation (sedges and submergent macrophytes), fine organic substrate and no flow;
- only one beaver pond (2 m deep) provided 700 m^2 of overwintering fish habitat (Plates 6.3-4 and 6.3-5); and
- only 100 m of stream habitat was found due to abundant beaver dams and lack of flow (Plates 6.3-3 and 6.3-6).

Plate 6.3-4. Shallow small beaver pond with sedge habitat.

Plate 6.3-5. Small beaver pond with sedge habitat that provides rearing and overwintering habitat.

Plate 6.3-6. Relic, dry beaver pond, which does not provide fish habitat.

Vegetation and Wildlife

Organic and mineral soils are present throughout the site and support a variety of riparian, terrestrial, and aquatic vegetation communities. Vegetation communities in the site include:

- wetland sedge and dry grass associations near ponds and channels (Plates 6.3-4 and 6.3-5);
- patches of alder and willow shrubs in wet areas;
- mature cottonwood forests on the alluvial fan and high bench areas of the floodplain (Plates 6.3-2 and 6.3-3); and
- mature coniferous forests on the adjacent rocky hill slopes (Plate 6.3-1).

Riparian vegetation includes willow, alder, sedges (Plate 6.3-4), grasses (Plate 6.3-6), cottonwood, spruce and fir (Plate 6.3-1). An assessment of provincially and federally rare ecosystems/plants (Rescan 2012e) indicated that rare plant species are not present at the site; however, provincially rare blue-listed ecosystems are present (Figure 6.3-2). The following blue-listed ecosystems are present:

- Fm03: Cottonwood – Subalpine Fir – Devil's Club (*Populus balsamifera - Abies lasiocarpa - Oplopanax horridus*)
- This middle-bench floodplain forest occurs on sandy or gravelly flats adjacent to streams and rivers with relatively prolonged flood durations. Cottonwood (*Populus balsamifera*) forms an open canopy with scattered subalpine fir and interior spruce. Devil's club is abundant in the understorey.

- Fl01: Mountain Alder – Common Horsetail (*Alnus incana – Equisetum arvense*)

  This lower bench floodplain occurs on sandbars along high gradient creeks that experience sporadic high-energy flooding. The site is dominated by mountain alder (*Alnus incana* subsp. *tenuifolia*), which typically forms a continuous canopy. The understory ranges from well-developed to sparse depending on the frequency and magnitude of recent flood events. Common horsetail (*Equisetum arvense*) is often present. The bryoid layer is generally very sparse or absent due to sedimentation and/or accumulation of litter.

- ICHvc/52 (Fl02): Mountain Alder - Lady Fern (*Alnus incana - Athyrium filix*)

  This ecosystem is found in wet depressions in the bottoms of gullies and adjacent to creeks. Mountain alder dominates the canopy, and the understory is lush and dense with ferns. This listed community is also called the Fl02 - Mountain alder - Red-osier dogwood – Lady fern (*Alnus incana - Cornus stolonifera – Athyrium filix-femina*). It represents an edaphic climax, as the conditions where it develops promotes the retention of the shrub community. Soils are usually cumulic, with inundation being evidenced by aggradations of sediments, especially fine sands.

- Ws06: Sitka Willow / Sitka Sedge (*Salix sitchensis- Carex sitchensis*)

  This swamp wetland is typically associated with fluvial systems or networks of depressions that experience extended saturation and ephemeral early-season flooding. The shrub and herb layers are dominated by Sitka willow and Sitka sedge, respectively. Additional large sedges such as water sedge (*Carex aquatilis*) and *C. utriculata* may also be present.

In addition to beavers, other wildlife signs observed included moose tracks and damaged shrubs browsed by moose. An assessment for western toad (*Anaxyrus boreas)* breeding habitat was conducted in 2011 (Rescan 2011b). Western toad is rare species and is designated as a "species of special concern" according to Committee on the Status of Endangered Wildlife in Canada and is present on Schedule 1 of the federal *Species at Risk Act* (2002). The species is also present on the red list published by the International Union for Conservation of Nature. During July breeding surveys, one juvenile western toad was observed at Treaty Creek - Site 1. No breeding sites were confirmed; however, western toads may not breed every year and wetland areas where adults or juveniles were observed, or where suitable habitat was identified, may still support western toad breeding in some years. Seven adult and six juvenile western toads were incidentally observed within the site during other periods.

Archaeology

An archaeology assessment was conducted at this site in 2011. This area was assessed to have low archaeological potential. Subsurface testing was conducted in areas of low archaeological potential to confirm the assessment, and no archaeological materials were recovered.

6.3.1.2 Fish Community and Habitat

Summer fish and fish habitat rearing assessments occurred in 2010 and 2011. A total of 224 hours of minnow trapping in the beaver pond complex in August 2010 captured parr and adult Dolly Varden and rainbow trout (Rescan 2011a; Table 6.2-2 and Figure 6.3-1). A total of 273 hours of minnow trapping in the beaver pond complex in August 2011 captured parr and adult Dolly Varden (Rescan 2012a). Catch per unit effort minnow trap data also demonstrated that Dolly Varden are more abundant in reference wetlands compared to wetlands within Treaty Creek - Site 1 (Rescan 2012a). Although Dolly Varden were captured upstream of beaver dams, the majority of fish were captured in the shallow sections of the beaver pond complex (i.e., downstream of beaver dam 3; Figure 6.3-1).

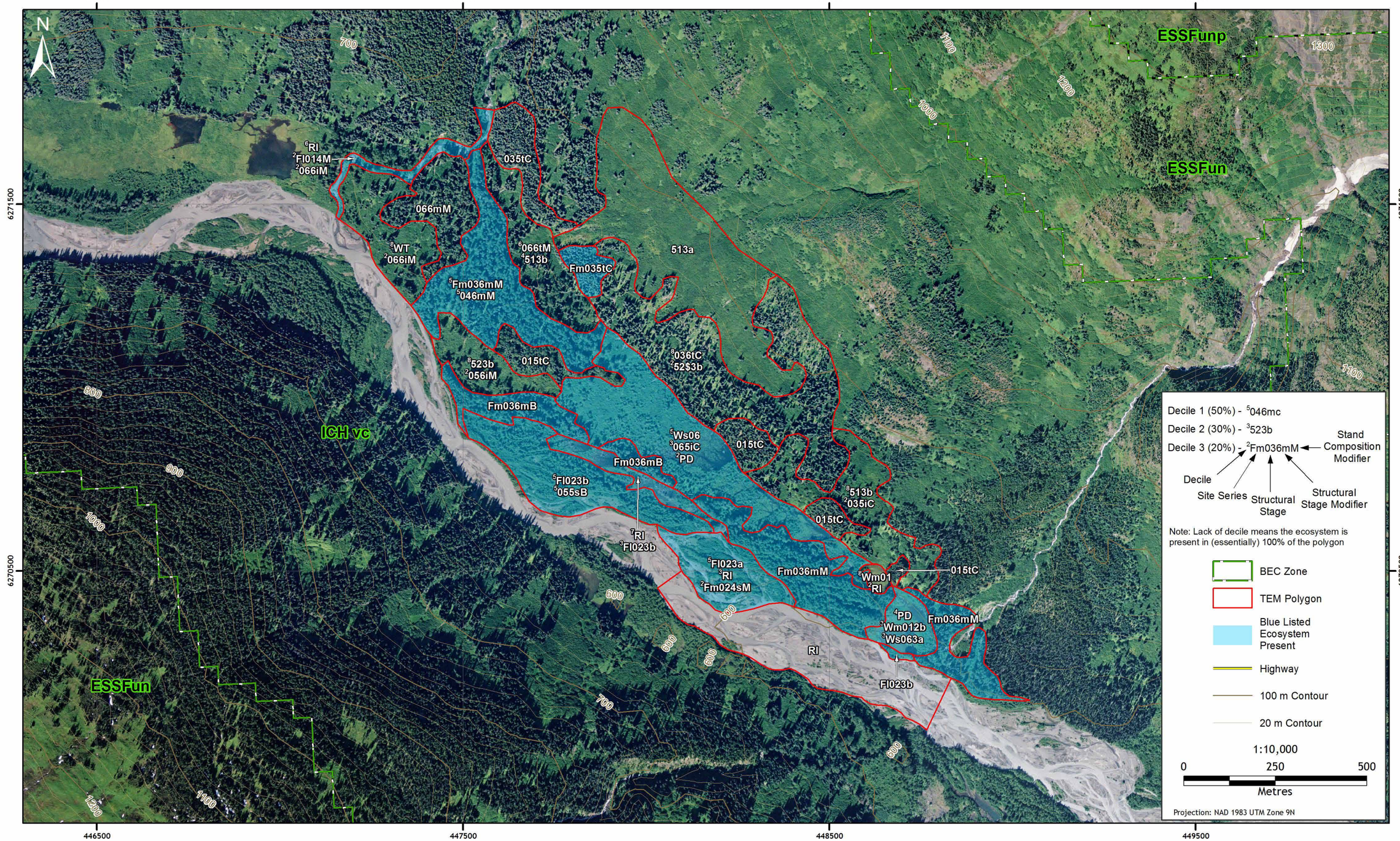

Figure 6.3-2

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Treaty Creek Site 1 - Terrestrial Ecosystems

Fish were not captured upstream of beaver dam 7 (Plate 6.3-6 and Figure 6.3-1). Although off-channel beaver ponds are preferred areas for juvenile coho salmon, none were captured. Coho salmon have not been sampled upstream of the Todedada Creek confluence in the Treaty Creek Watershed.

Fish habitat quality was considered poor in August 2010 and 2011 in most of the shallow beaver ponds due to the lack of flow, stagnant, shallow water, and organic substrate (Table 6.2-4). Only a few areas were fair to good quality rearing and overwintering habitat; these included the deeper channels and ponds near beaver dams 6 and 7. Cover in the form of logs, stumps, and brush was not abundant, whereas instream sedges and overhanging vegetation provided abundant cover throughout the site.

Substrate in the existing channels between beaver ponds was mainly organic. Salmonid spawning habitat does not exist at Site 1. Gravel substrate was only observed at two locations; the pond outlet near beaver dam 1 and the adjacent Creek 2 ephemeral channel.

Winter fish and fish habitat rearing assessments occurred in 2010 and 2011. In the winter of 2010, several off-channel areas were identified in the Treaty Creek Watershed (Rescan 2011a). Ponds were observed with up to 1.2 m of ice in the Treaty Creek Watershed. Shallow ponds were frozen to the bottom. Overwintering habitat quality was strongly influenced by the presence of winter base flow, groundwater seepage, and ice thickness. Most of the existing beaver ponds in Site 1 provide poor quality overwintering habitat; only one deep pond provides fair quality overwintering habitat.

In the winter of 2011, the deepest wetlands were sampled. Mean ice thickness was 0.6 m, and mean water depth was 0.5 m. No fish were caught, and dissolved oxygen concentrations were low (2.5 mg/L). Open water was present in the eastern half of the compensation site with mean water depths of 0.1 cm. The open water was likely due to groundwater influence from adjacent Creek 2 on the eastern end of the site. A reference wetland was selected in the Treaty Creek Watershed for comparisons of ice depth, dissolved oxygen concentrations, and fish habitat use. Ice thickness, mean water depth, and dissolved oxygen concentrations were similar to that of Treaty Creek Site 1.

In summary, the existing habitat at Site 1 is of poor quality with obstructed fish access and low overall fish productivity (Table 6.2-4). Fish access through the beaver pond complex is obstructed by five beaver dams and fish cannot access habitat upstream of dams. Contributing to the fish access problem is the lack of perennial flow, lack of water depth, mainly organic substrate, and discontinuous channels between ponds (Table 6.2-4). Typically, coho salmon juveniles rear in off-channel areas similar to Site 1, but their absence is likely due to a combination of these limitations. These limitations were also observed at other compensation sites and off-channel areas throughout the watershed.

6.3.2 Objectives and Technique

Site 1 in the Treaty Creek Watershed provides a unique opportunity to divert water from North Treaty Creek into a protected side channel and off-channel complex consisting of deep ponds and channels. The proposed project will provide a large amount of permanent, good quality habitat for rearing, overwintering and spawning. It will support all life stages of the two target species: Dolly Varden and coho salmon (Table 6.2-3 and 6.2-5). The BC MOE has developed provincial fisheries management objectives for species (e.g., Dolly Varden) other than migratory Pacific salmon. DFO is responsible for the management of migratory Pacific salmon (e.g., coho salmon). Therefore, this site will address fisheries management objectives for DFO and provincial fisheries agencies and provide multi-species benefit as indicated in Table 6.2-5.

The objectives for Site 1 are to:

- construct a surface water intake from North Treaty Creek to supply reliable flow into a protected side channel and through a series of ponds;

- create 15.38 ha of good quality overwintering and rearing habitat in ponds;
- construct 2,118 m of channels to create 0.42 ha of habitat with complex features (pools, riffles, wood, and boulders);
- enhance the functional aspects of wetland ecosystems (e.g., nutrient recycling, water quality improvement, and fish and wildlife habitat);
- provide spawning habitat for coho salmon and Dolly Varden using wood cover, gravel substrate, and deep pools within the constructed channels; and
- maintain fish access and prevent beaver dam construction with beaver-proof fencing and wood structures at pond outlets.

The 0.45 ha of existing poor quality, shallow fish habitat in Site 1 will be replaced with a total of 15.8 ha of good quality habitat. This is greater than a 20 fold increase in habitat at the site that will be included in the HU budgeting.

A secondary outcome of this off-channel fish habitat project is the enhancement of key wetland functions. These include providing additional fish and wildlife habitat, water quality improvement, water storage, and nutrient cycling. By enhancing these functions, this site will support the wetland habitat mitigation goals throughout the KSM Project area.

6.3.3 Proposed Design

The preliminary site layout is provided in Figures 6.3-3 and 6.3-4 (a to f), and the proposed components and features are described below. The off-channel concept is described in Section 6.1. The proposed project includes:

- 2,118 m of excavated stream channels;
- a water intake from North Treaty Creek leading into the off-channel complex;
- flow control structures;
- 15.38 ha of ponds; and,
- an outlet channel to Treaty Creek.

The channels will provide high quality rearing habitat for juvenile coho and Dolly Varden during the ice-free period. The pools in the channels will supply overwintering habitat in addition to the large ponds. The typical pond and channel layout and profile views are shown in Figures 6.1-1 to 6.1-3 and 6.3-4f. Final channel dimensions and layout will be shown on construction drawings.

The typical wetted width of the channel will be 2 m and the channel incision will be 1.5 to 3 m deep. Water depth in channels will depend on slope and will range from 0.05 to 0.3 m (excluding pool depth). The channel will be complexed with salvaged materials (i.e., cobble, boulders, LWD, and root wads) such that approximately 50% of the channel has overhead or instream cover. Logs and root wads will be partially buried in the bank or cabled to boulders for stability (additional details on anchoring of LWD is presented in Section 6.1). The typical channel arrangement and details are shown in Figure 6.1-3.

Small pools will be excavated along the constructed channels every 20 to 30 m (Figure 6.1-1). Typical pools will be designed to have 1 m residual depth. They will be complexed with wood, branches, and boulders to provide cover. The gravel tailouts of pools will provide spawning habitat for the target species.

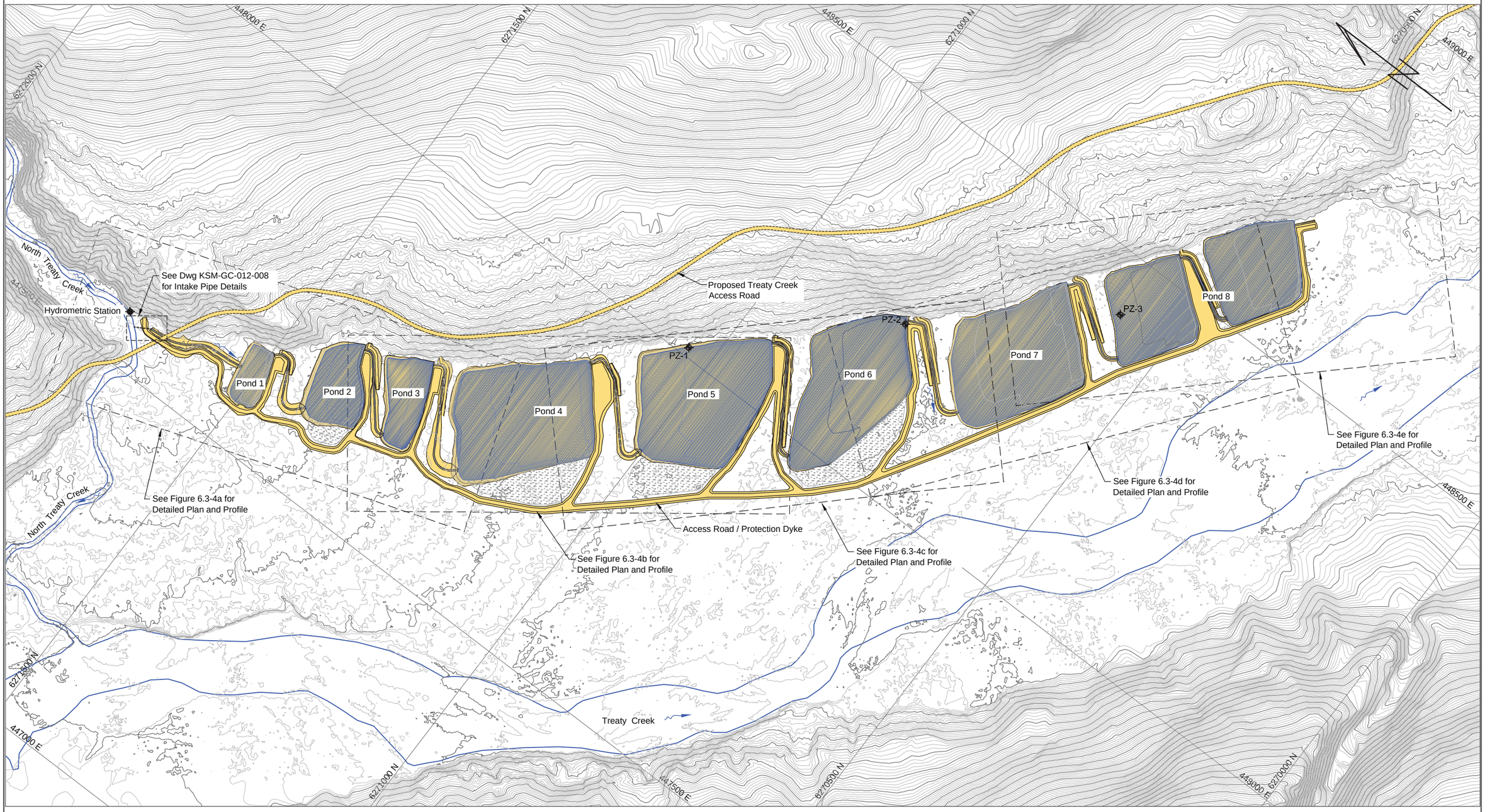

Figure 6.3-3

Treaty Creek Site 1 - Plan View

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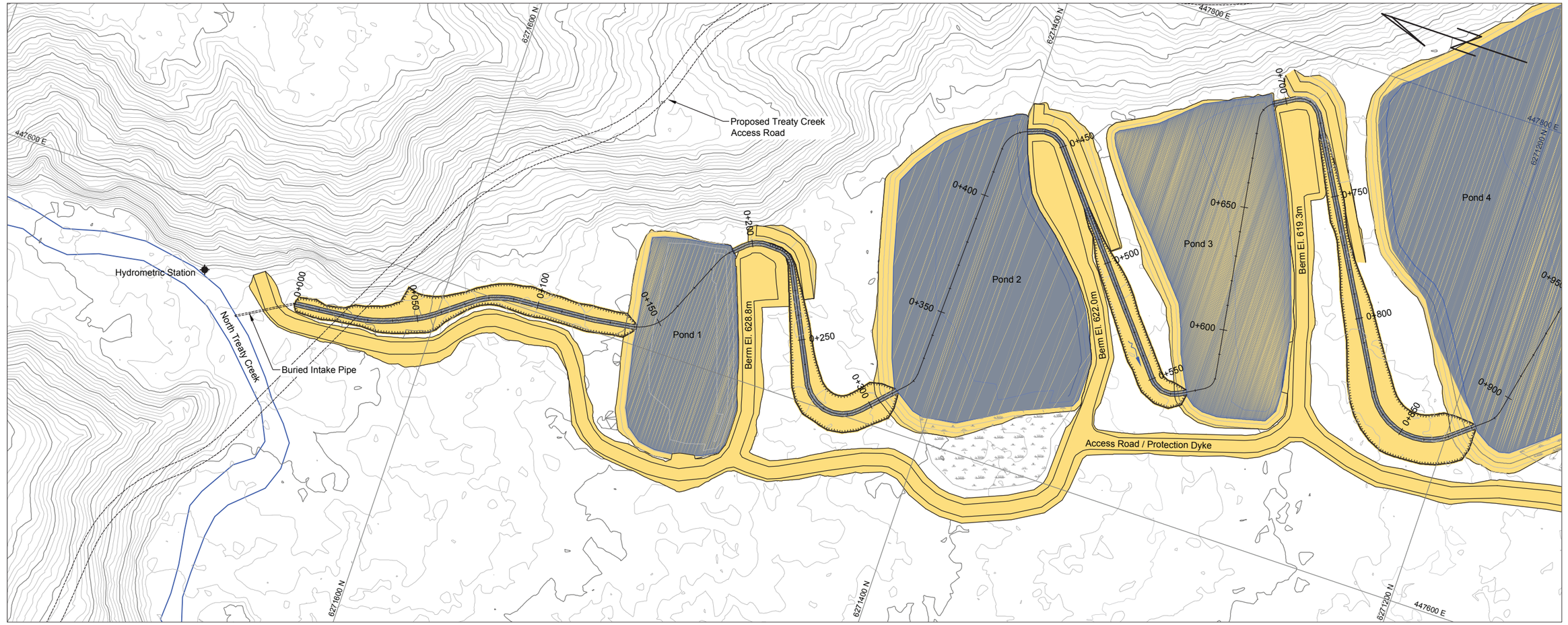

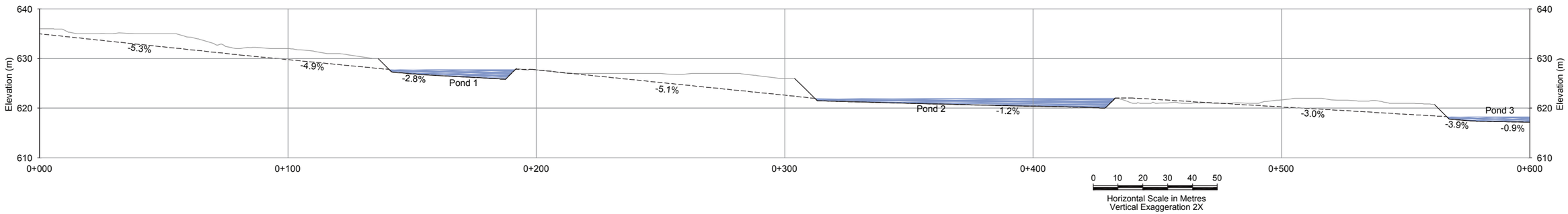

Figure 6.3-4a

Treaty Creek Site 1 – Plan and Profile View (Station 0+000 to 0+600)

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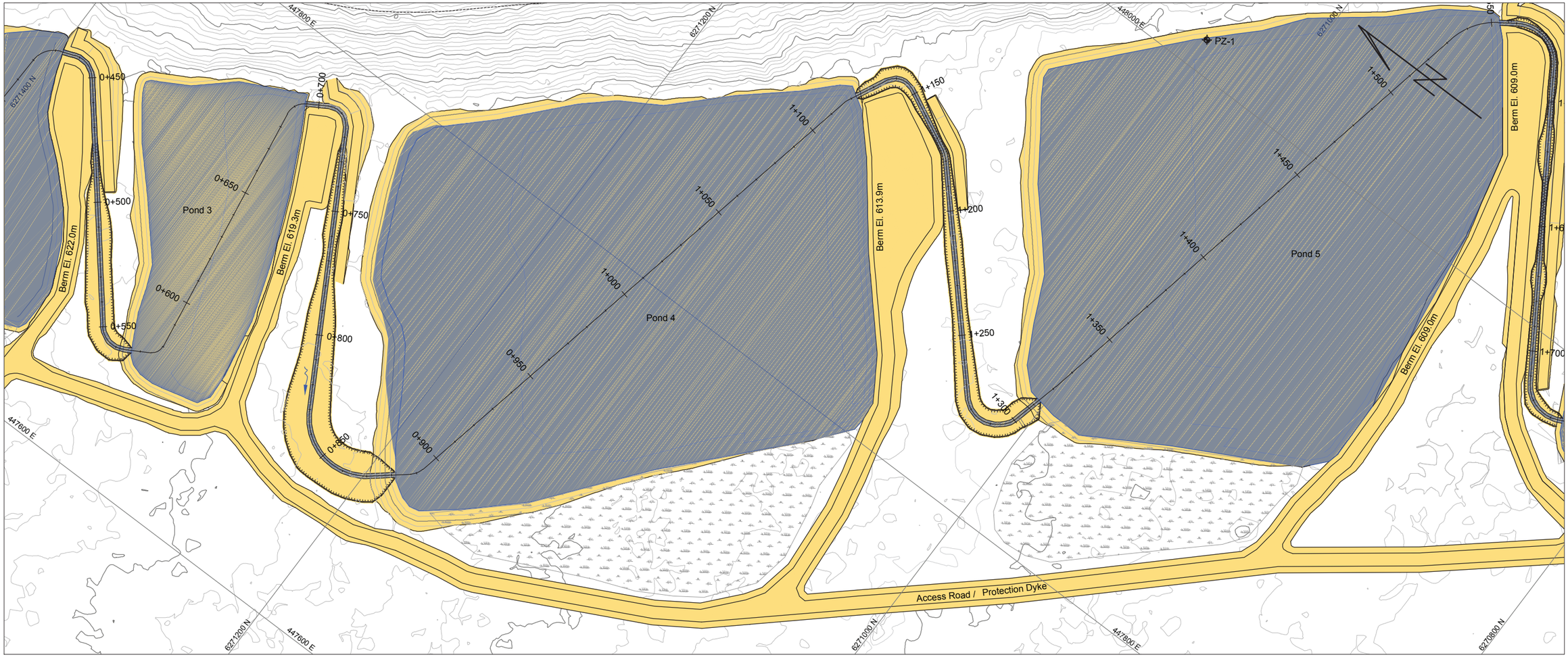

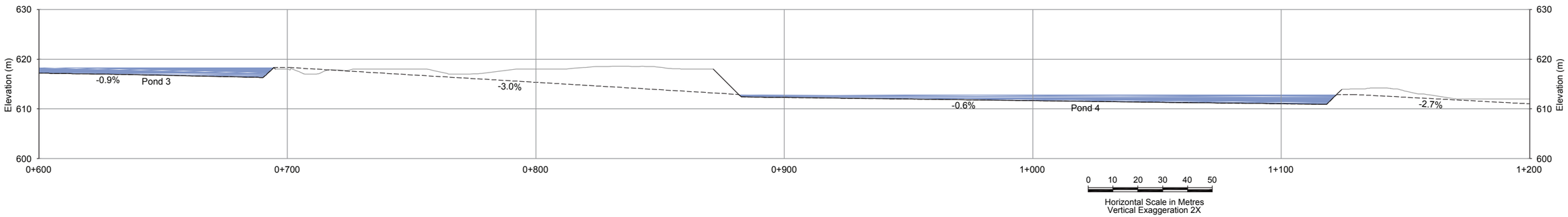

Figure 6.3-4b

Treaty Creek Site 1 - Plan and Profile View (Station 0+600 to 1+200)

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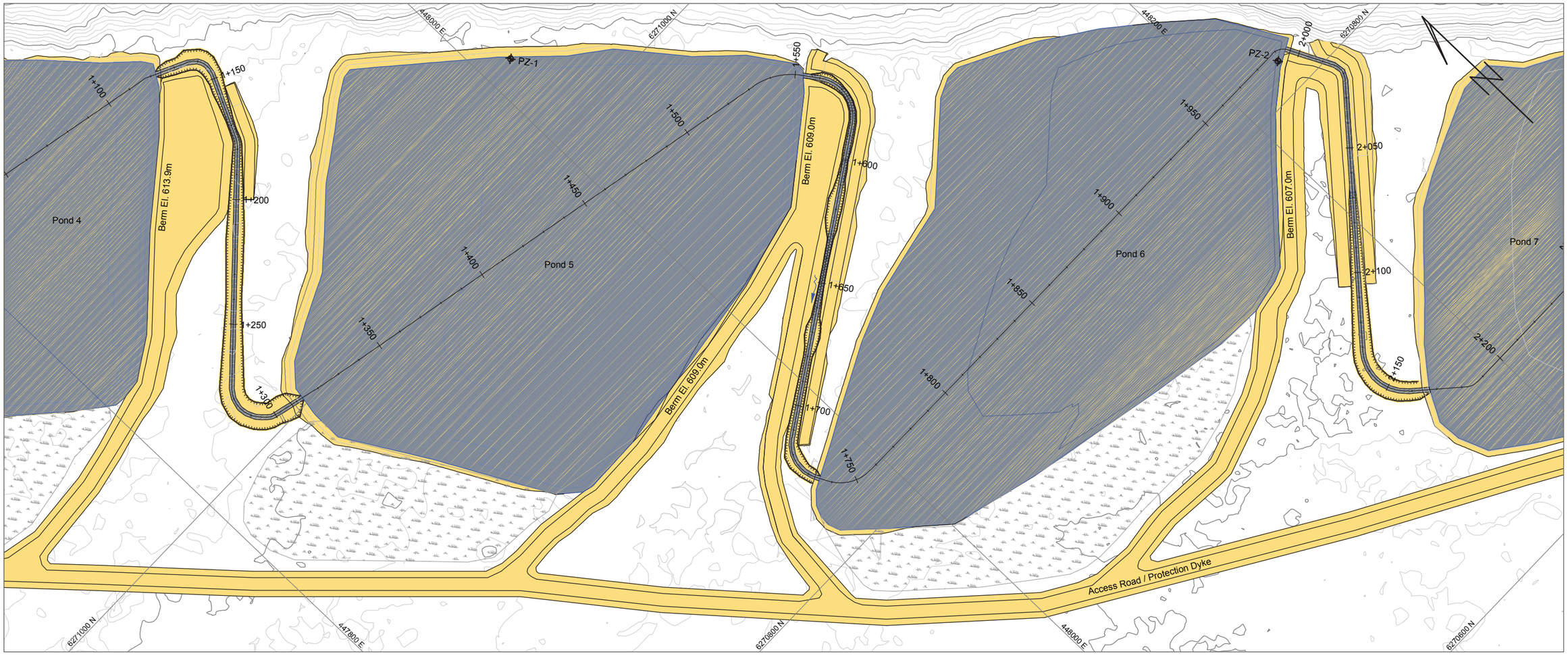

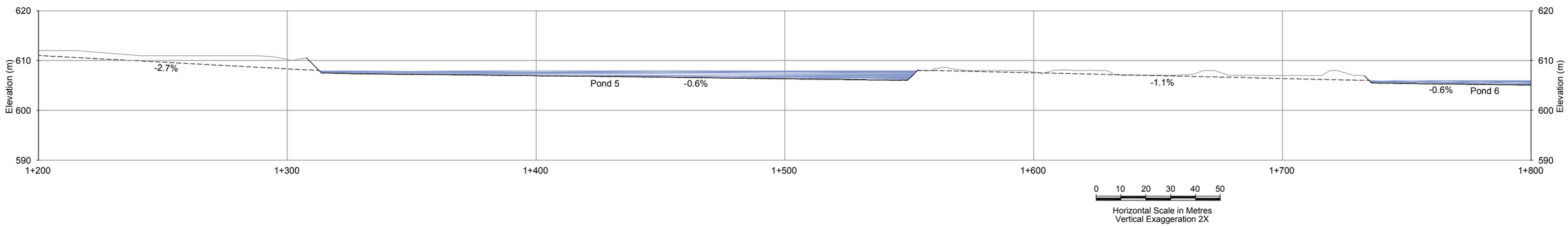

Figure 6.3-4c

Treaty Creek Site 1 - Plan and Profile View (Station 1+200 to 1+800)

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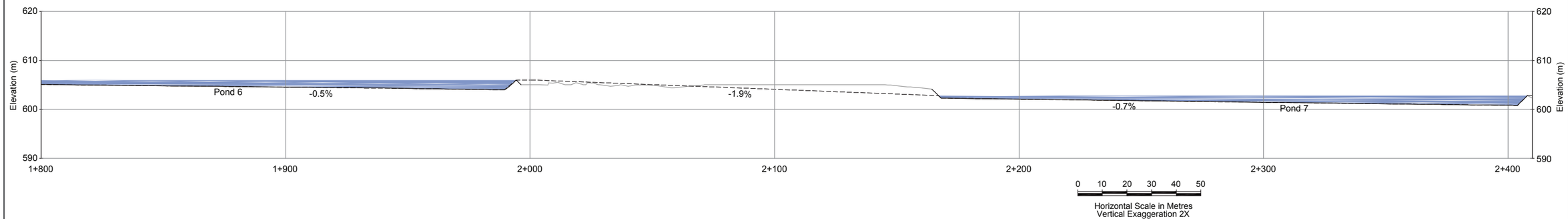

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Figure 6.3-4d

Treaty Creek Site 1 - Plan and Profile View (Station 1+800 to 2+410)

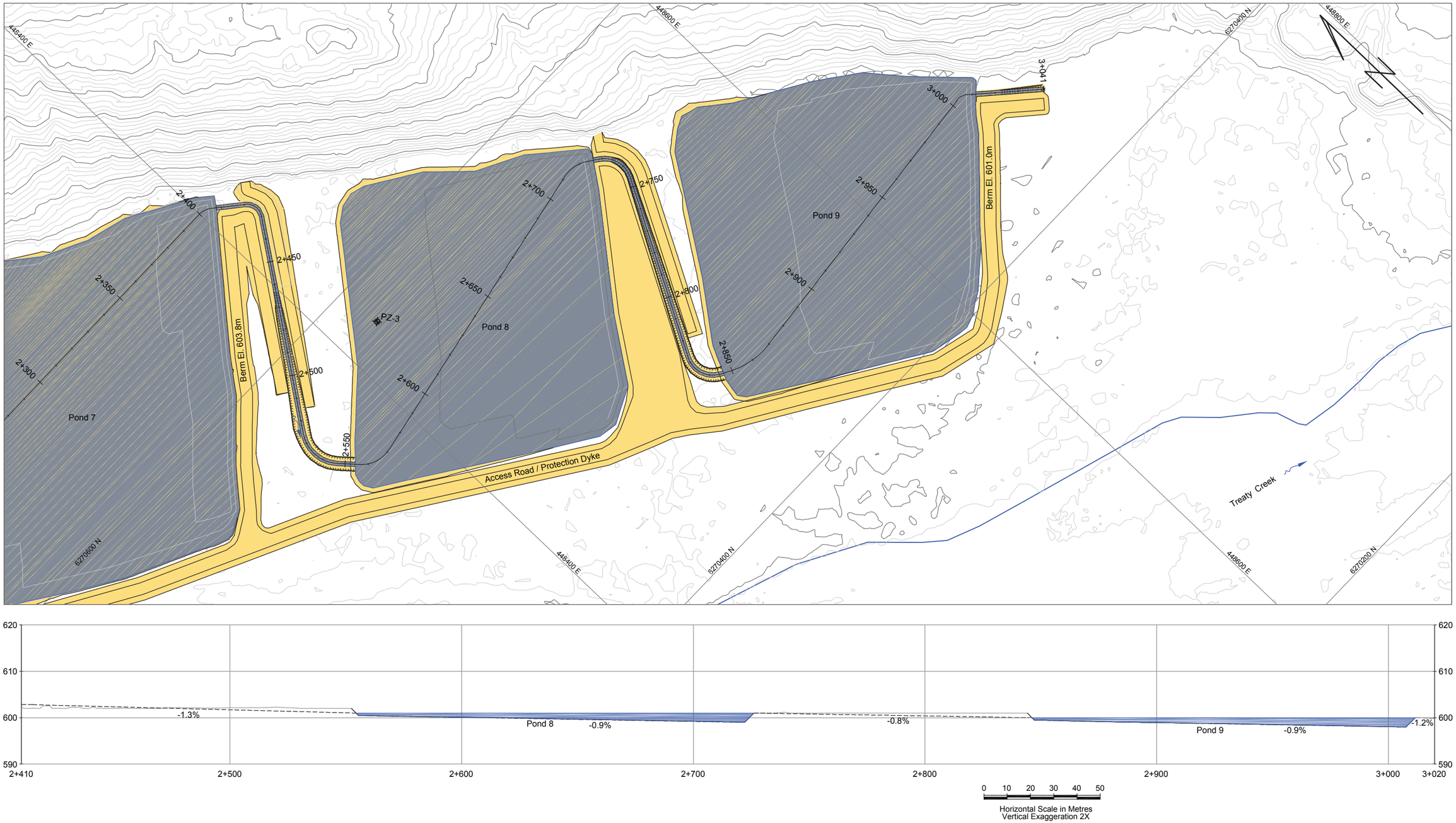

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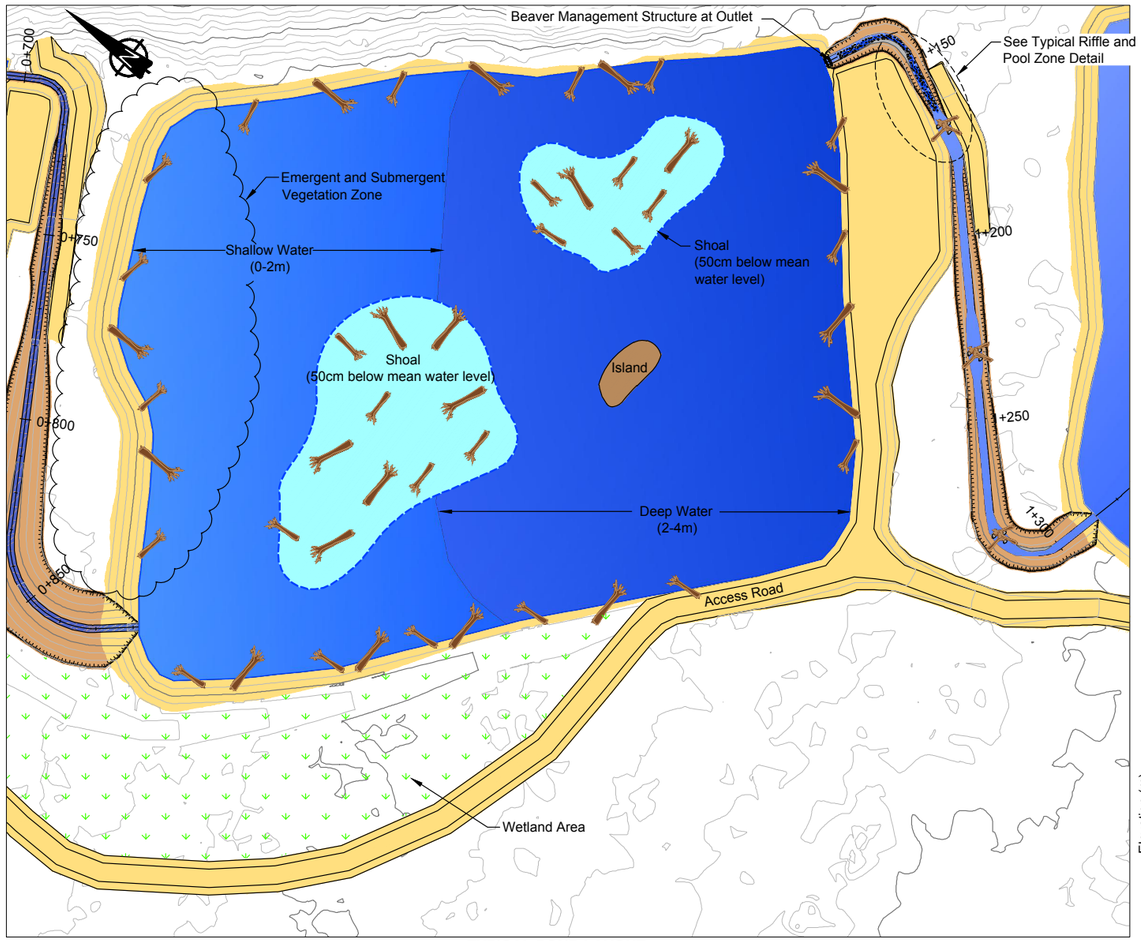
Figure 6.3-4e

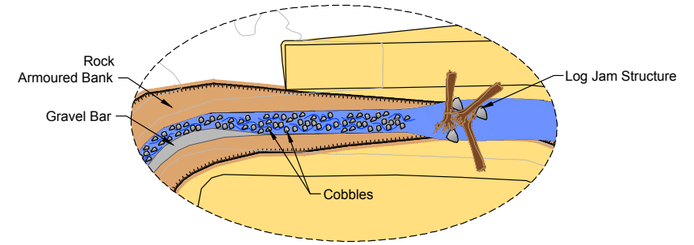
Treaty Creek Site 1 – Plan and Profile View (Station 2+410 to 3+020)



TYPICAL POND LAYOUT

0 5 10 15 20 25

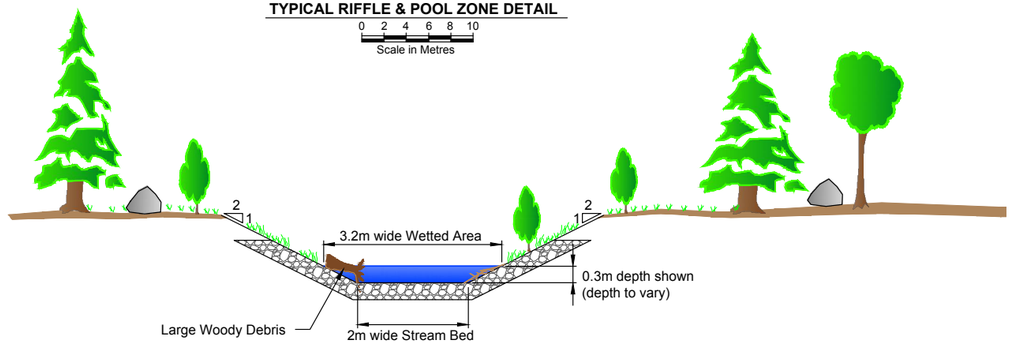
Scale in Metres



TYPICAL RIFFLE & POOL ZONE DETAIL

0 2 4 6 8 10

Scale in Metres



TYPICAL RUN ZONE CHANNEL SECTION

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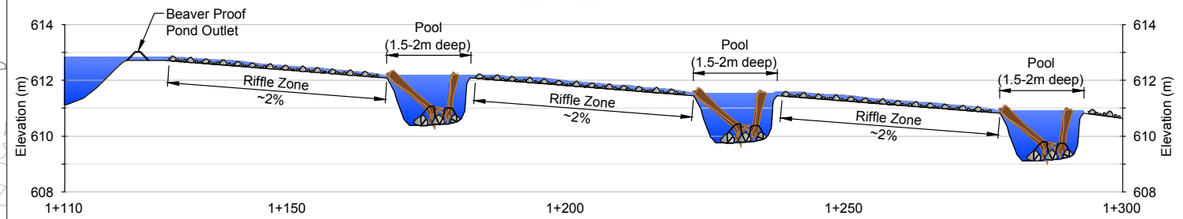
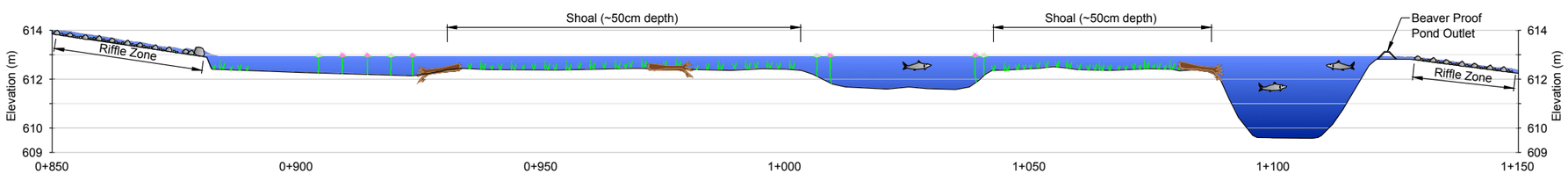
Scale in Metres



TYPICAL CHANNEL PROFILE

0 5 10 15 20 25

Horizontal Scale in Metres
Vertical Exaggeration 5X



TYPICAL POND PROFILE

0 5 10 15 20 25

Horizontal Scale in Metres
Vertical Exaggeration 5X

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Figure 6.3-4f

Treaty Creek Site 1 - Pond and Channel Typical Plan and Sections

The channel will be sinuous with riffle/run/pool morphology and gradients from 0.5 to 4%. The channel will carry water from the North Treaty Creek intake at 635 masl through the upper pond and down the alluvial fan to a lower pond (596 masl). Excavated material will be deposited alongside the channel to form a tote road. The working corridor will be 15 to 20 m wide. Site preparation work prior to excavation will include tree felling and root wad grubbing; trees and root wads will be incorporated as fish habitat features within the channel.

Materials excavated from the channel and ponds will be used to build a gravel dike along the floodplain adjacent to Treaty Creek. The gravel dike will help prevent flooding to the off-channel complex and serve as an access road.

Nine large bermed ponds will replace the existing beaver dams at this site (Figure 6.3-3). The constructed ponds will range from approximately 0.34 to 2.79 ha and will be up to 4 m deep (Figures 6.1-1, 6.1-2, and 6.3-3). Each pond will be fit to the local topography and existing aquatic features and fish will be salvaged prior to construction (e.g., sedges, wood, etc.). Beaver fencing and beaver structures (e.g., wood accumulations) will be built to prevent channel blockage and damage.

Water supply for the off-channel complex will come from three sources (in order of contribution amount): surface water from North Treaty Creek and Creek 1 (spring/summer only) as well as intercepted groundwater. A water intake structure will be constructed along the east bank of North Treaty Creek at the apex of the alluvial fan (bottom left of Plate 6.3-1). The intake will be a buried pipe and will not be fish passable. The withdrawal amount will be determined based upon flow monitoring in North Treaty Creek and design volumes for the channels.

Construction of this site will require extensive excavation. Excavators, bulldozers, and dump trucks will be required to move materials. No road access to the site exists; however, the proposed Treaty Creek Access Road will be constructed immediately adjacent to the compensation site. Logs and rocks will likely be sourced from the excavated footprint.

6.3.4 Habitat Gain Summary

Tables 6.3-1 and 6.3-2 summarize stream and wetland habitat gain for the compensation site. Because fish habitat already exists at the compensation site, the existing value of the habitat must be subtracted from the planned enhanced value of the compensation habitat. Dolly Varden stream HSI was used for HU calculation. Coho salmon is a target species for the site as well; however, coho salmon stream HSI was not used for HU calculation because coho salmon have not been sampled upstream of the Todedada Creek confluence in the Treaty Creek watershed. A total of 279,403 HUs and 153,927 m^2 will be gained from this site.

Table 6.3-1. Treaty Creek - Site 1: Stream Habitat Creation Summary

Altered or Created	Area (m^2)	Dolly Varden Stream Habitat								Total HU
		Adult		Embryonic Stage		Fry Rearing		Parr Rearing		
		HS	HU	HS	HU	HS	HU	HS	HU	
Existing	150	0.5	75	0.1	15	0.1	15	0.1	15	120
Created	4,237	1	4,237	1	4,237	0.5	2,119	0.5	2,119	12,711
Total	**4,087**									**12,591**

Table 6.3-2. Treaty Creek - Site 1: Wetland Habitat Creation Summary

Altered or Created	Area (m^2)	Wetland Habitat				Total HU
		Rearing		Overwintering		
		HS	HU	HS	HU	
Existing	240	0.1	24	0.1	24	48
Existing	800	0.1	80	0.1	80	160
Existing	200	0.1	20	0.1	20	40
Existing	700	0.75	525	0.5	350	875
Existing	80	0.25	20	0.25	20	40
Existing	225	0.5	113	0.25	56	169
Existing	600	0.25	150	0.25	150	300
Existing	1,500	0.25	375	0.25	375	750
Created	153,825	1	153,825	0.75	115,369	269,194
Total	**149,480**					**266,812**

6.3.5 Taft Creek - Site 1

6.3.5.1 Site Description

Location

Taft Creek is a large, fourth-order tributary to the Bell-Irving River, comparable in size to Teigen and Treaty creeks (Figure 6.2-2). It drains west from a range of steep mountains and contains important fish and fish habitat resources.

Site 1 is located on the east side of Taft Creek between the Highway 37 bridge and confluence with the Bell-Irving River, approximately 1 km downstream (Figure 6.3-5). It is 35 km south of Bell 2 Lodge. The centre of the proposed project is at UTM 9V.473400 E, 6261300 N. The site is easily accessible from Highway 37.

This site is 1 km long and approximately 300 m wide (Figure 6.3-5; Plates 6.3-7 to 6.3-12). It includes low bench and high bench floodplain terraces on the southeast bank of Taft Creek. A strip of mature coniferous forest, up to 50 m wide, occupies the high bench. Deciduous pole-sapling forest exists along the low bench floodplain. The braided channel of Taft Creek is active at this site with occasional inundation of the flood channels. The bridge controls the location of Taft Creek; bedrock banks and bridge infrastructure prevent lateral channel migration at the bridge site (Plate 6.3-8).

Aside from the two mainstem channels, several flood channels and a small seepage channel exist at the proposed site (Figure 6.3-5).

Vegetation and Wildlife

Taft Creek Site 1 is situated in mature mixed forest dominated by a canopy of black cottonwood (*Populus trichocarpa*), hybrid white spruce (*Picea glauca x engelmannii*), and subalpine fir. The understory is composed of varying amounts and density of devils club, huckleberry (*Vaccinium* spp.), alder, and willow depending on the disturbance intervals and subsequent light regime. Ecosystem structure and composition varies in association with parent materials, disturbance severity, and flooding frequency.

The active floodplains have a higher component of black cottonwood, alder, and willow, which colonize quickly after disturbance (flooding) and tolerate long periods of saturation within the rooting zone. At this site, soils tend to be medium to coarse textured. However, layers of finer textured soils are also present, due to deposition during lower energy flood events.

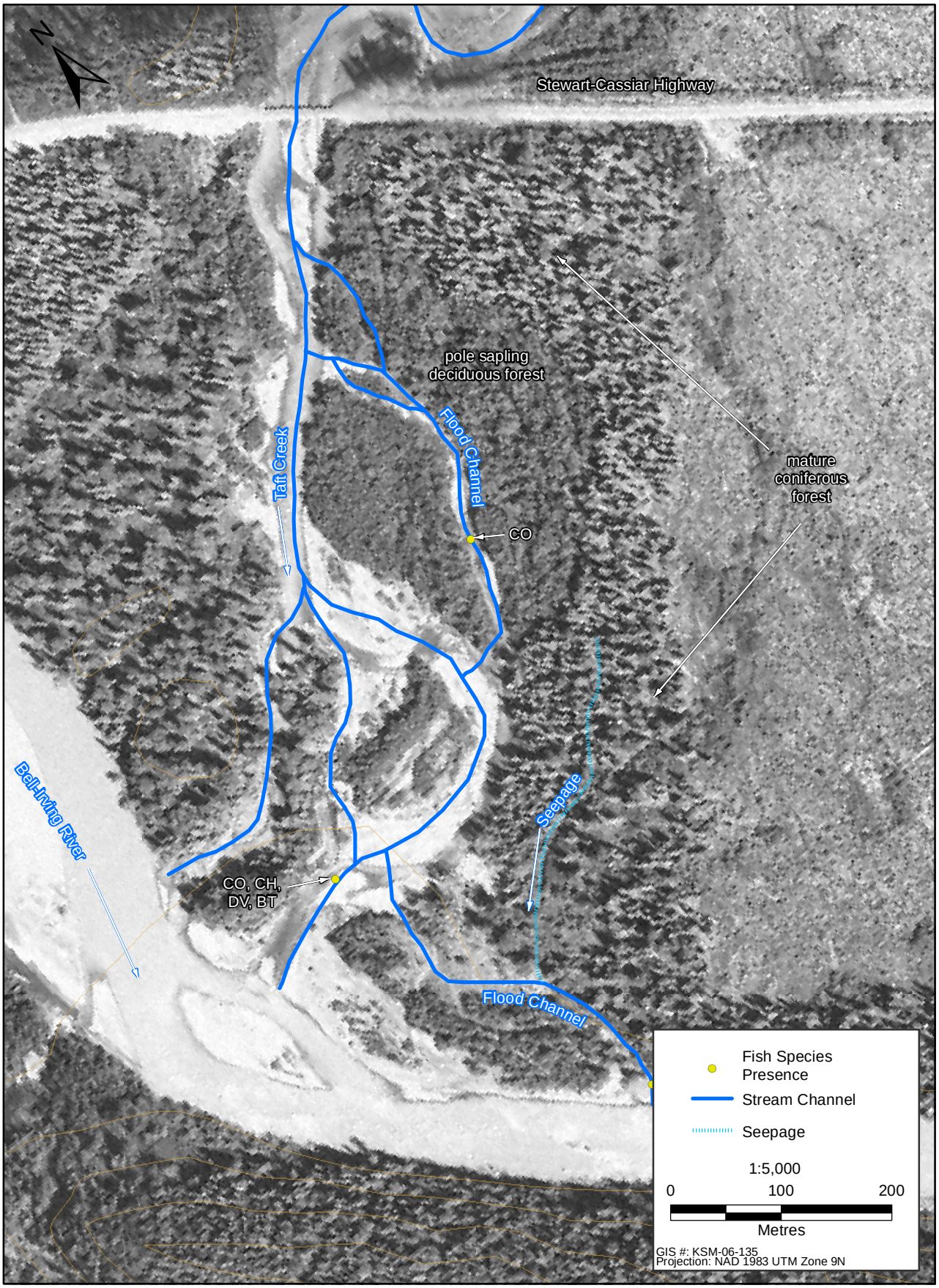

Figure 6.3-5

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Taft Creek Site 1 - Existing Conditions

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Plate 6.3-7. Upstream view of confluence of Taft Creek and Bell-Irving River; proposed compensation site is along right side of photo.

Plate 6.3-8. Downstream view of Highway 37 North and Taft Creek Bridge. Surface intake would occur either up or downstream of the existing bridge. Mature stand of conifers in the photo's centre is location of proposed side channel and groundwater channel site.

Plate 6.3-9. Dry cobble flood channel in pole-sapling cottonwood forest along active floodplain.

Plate 6.3-10. Back eddy outlet of seepage channel located just upstream of the confluence with Bell-Irving River. Peak flows inundate up to 100 m upstream of this point in the back channel.

Plate 6.3-11. Dry cobble/gravel bar situated adjacent to Taft Creek.

Plate 6.3-12. Aerial view of proposed side channel locations, facing east, on the east side of Taft Creek among deciduous and coniferous forest patches.

Inactive floodplains along Taft Creek - Site 1, classified as Hybrid Spruce - Devil's club (ICHvc03) and Hybrid Spruce - Devil's club - Dogwood (ICHvc04) are characterized by significant components of both

hybrid white spruce and subalpine fir. The soils are very coarse and are dominated by cobbles and boulders. These are associated with very high energy, uncommon flood events. The nature of these soils allows for the sites to become quite dry during the summer months, as rainfall quickly drains from the rooting zone.

An assessment of provincially and federally rare ecosystems/plants (Rescan 2012e) indicated that rare plant species are not present at the site; however, a provincially rare red-listed ecosystem is present (Figure 6.3-6). The following red-listed ecosystem is present:

- Fm02: Balsam Poplar, Black Cottonwood - Spruces / Red-osier Dogwood (*Populus balsamifera* (ssp. *balsamifera*, ssp. *trichocarpa*) - *Picea* spp. / *Cornus stolonifera*)

  This middle bench floodplain forest occurs on sandy or gravelly materials along major rivers that experience regular surface flooding and occasional over-bank flooding every one to five years. Cottonwood forms an open canopy with scattered spruce. Species composition is restricted to flood tolerant species such as red osier dogwood (*Cornus stolonifera*), highbush cranberry (*Veratrum viride*), and horsetail (E*quisetum arvense*).

Wildlife sign observed included moose tracks and damaged shrubs browsed by moose. An assessment for western toad breeding habitat was conducted in 2011 (Rescan 2011b). Western toad is rare species, and is designated as a "species of special concern" according to Committee on the Status of Endangered Wildlife in Canada and is present on Schedule 1 of the federal *Species at Risk Act* (2002). The species is also present on the red list published by the International Union for Conservation of Nature. During July breeding surveys, one juvenile western toad was observed at Taft Creek - Site 1. No wetland habitats are present at the site; therefore breeding sites are not present. Western toads were not observed at the site.

Archaeology

An archaeology assessment was conducted at this site in 2011. This area was assessed to have low archaeological potential. Subsurface testing was conducted in areas of low archaeological potential to confirm the assessment, and no archaeological materials were recovered.

6.3.5.2 Fish Community and Habitat

Taft Creek supports chinook and coho salmon, rainbow trout/steelhead, Dolly Varden, bull trout, and mountain whitefish (Rescan 2011a). Fish can access the good quality habitat in the mainstem for at least 25 km upstream of the Bell-Irving River.

Juvenile Dolly Varden, bull trout, rainbow trout, and chinook and coho salmon varied in abundance and distribution throughout Taft Creek habitat types (e.g., mainstem, lower reaches of tributaries, side channels, and off-channel areas [Rescan 2011a]). Sampling in the turbid mainstem and active flood channels adjacent to the proposed compensation site found abundant chinook salmon fry in riffles along with a few juvenile char and adult bull trout in runs (Figure 6.3-4). Isolated pools and slow velocity seepage areas on the flood channels beside the proposed compensation site contained a low abundance of coho salmon fry.

A side channel complex, situated 500 m upstream of the proposed compensation site on the Taft Creek floodplain, supports coho fry along with Dolly Varden parr and adults, although access is limited. Small tributaries that cross the highway near Taft Creek and the proposed compensation site support juvenile Dolly Varden (FINS 2004; Rescan 2011a).

Fish habitat in Taft Creek mainstem and flood channels near the proposed compensation site consists mainly of swift, deep cobble runs and glides, which provide adult rearing and holding habitat. The margins of the cobble runs and riffles in adjacent flood channels provide good quality rearing habitat for chinook salmon and char.

Between 5 and 25 km upstream of the proposed compensation site, chinook fry and bull trout fry and parr were also abundant in riffles and cobble margins. Adult chinook salmon, bull trout, and Dolly Varden used deeper glides for holding in the upper mainstem reaches.

Spawning habitat quality in the mainstem downstream of Highway 37 is poor due to the cobble substrate and swift flow. Spawning habitat for salmon is located mainly in the middle sections of Taft Creek, between 10 and 20 km upstream of the highway. Fair to good quality spawning habitat with abundant gravel runs and pools exists in the middle reaches.

6.3.6 Objectives and Technique

The proposed compensation site will provide a large amount of good quality habitat for rearing and overwintering along with a small amount of spawning habitat. It will support the two target species: Dolly Varden and coho salmon (Table 6.2-3). Rainbow trout fry and chinook salmon fry may use the constructed site to a minor amount given their preference for moderate velocity summer rearing habitat.

The objectives for Taft Creek - Site 1 are to:

- create 4.47 ha of good quality off-channel overwintering and rearing habitat in ponds;
- construct 968 m of stream channels to create 0.19 ha of rearing habitat with complex habitat features (pools, riffles, wood, and boulders); and
- maintain fish access and prevent beaver dam construction with beaver-proof fencing and wood structures at pond outlets.

6.3.7 Proposed Design

The design includes a series of ponds, berms, and channels (Figure 6.3-7 and 6.3-8 [a to d]). Taft Creek - Site 1 will consist of a groundwater-fed channel with and optional surface intake (if required) from Taft Creek into a protected off channel complex, which will drain into the Bell-Irving River. The design considerations for off-channel concepts are provided in Section 6.1. The typical off-channel pond layout and cross-sections are shown in Figures 6.1-1 to 6.1-3 and 6.3-8d.

The protected off-channel complex will consist of:

- a groundwater collection channel;
- a surface intake from Taft Creek in the vicinity of the Highway 37 bridge;
- 968 m of excavated channel;
- a spoil dike/tote road on the west side;
- ten ponds containing wood and cover features; and
- an excavated outlet channel to the Bell-Irving River.

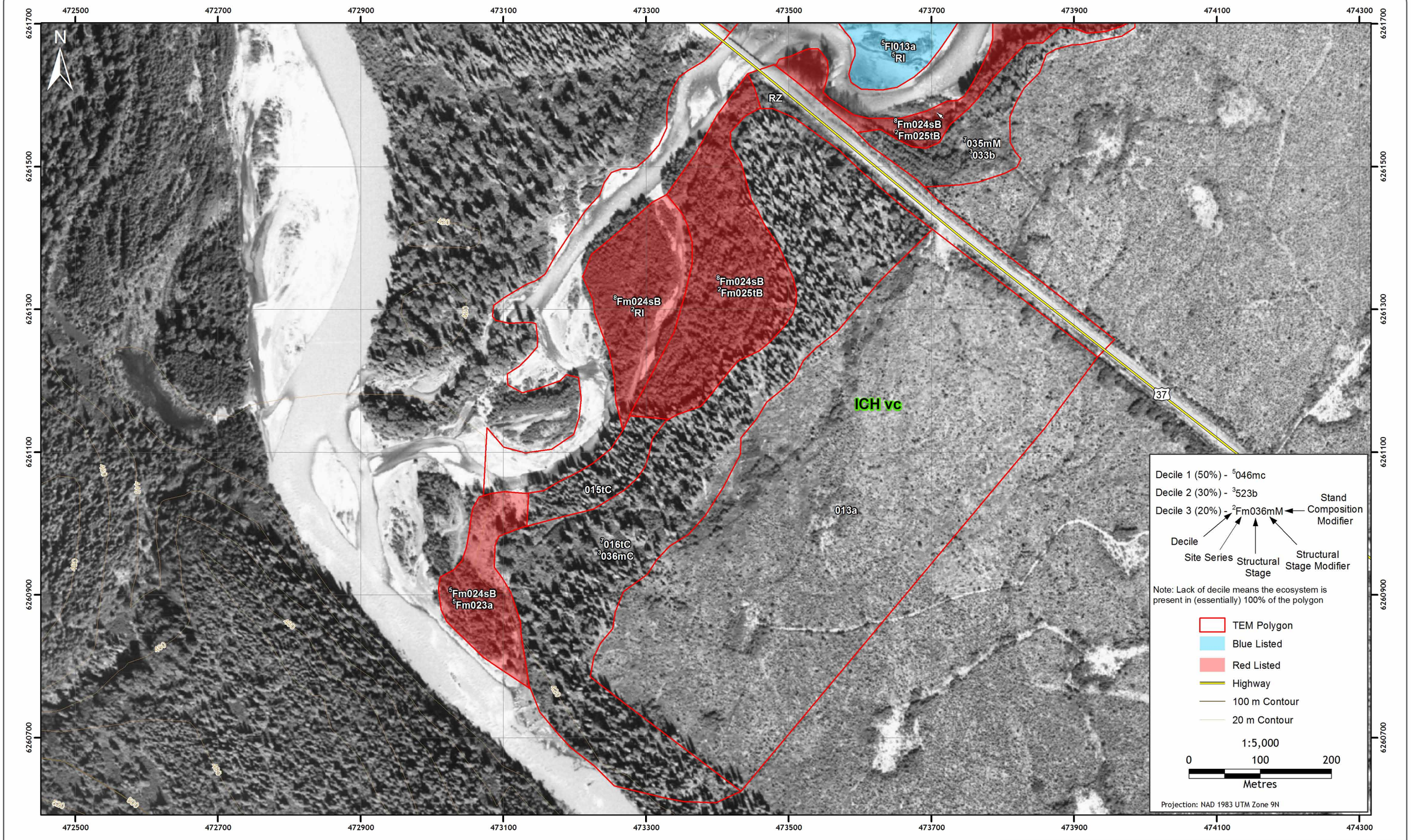

Figure 6.3-6

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Taft Creek Site 1 - Terrestrial Ecosystems

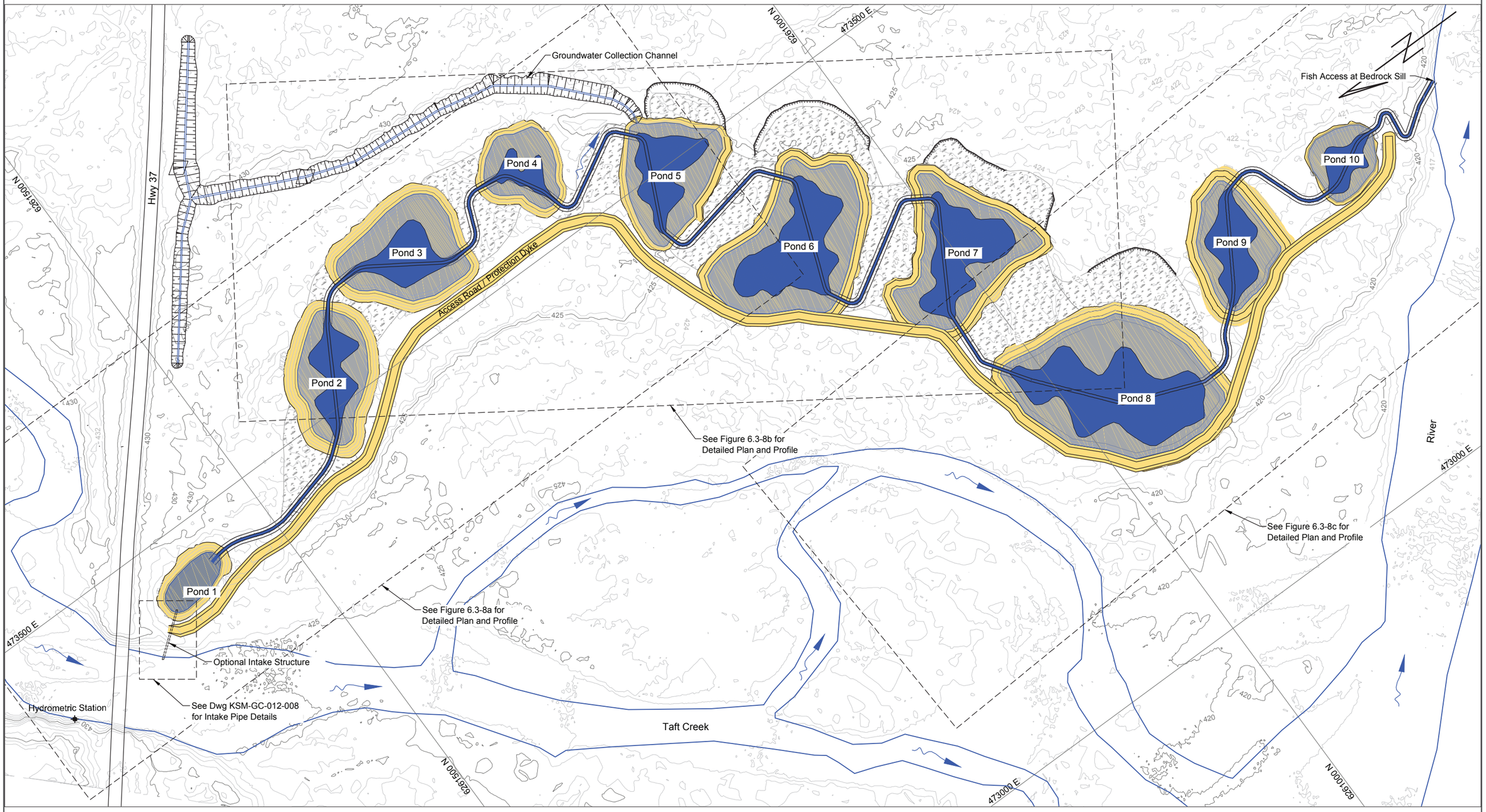

Figure 6.3-7

Taft Creek Site 1 - Plan View

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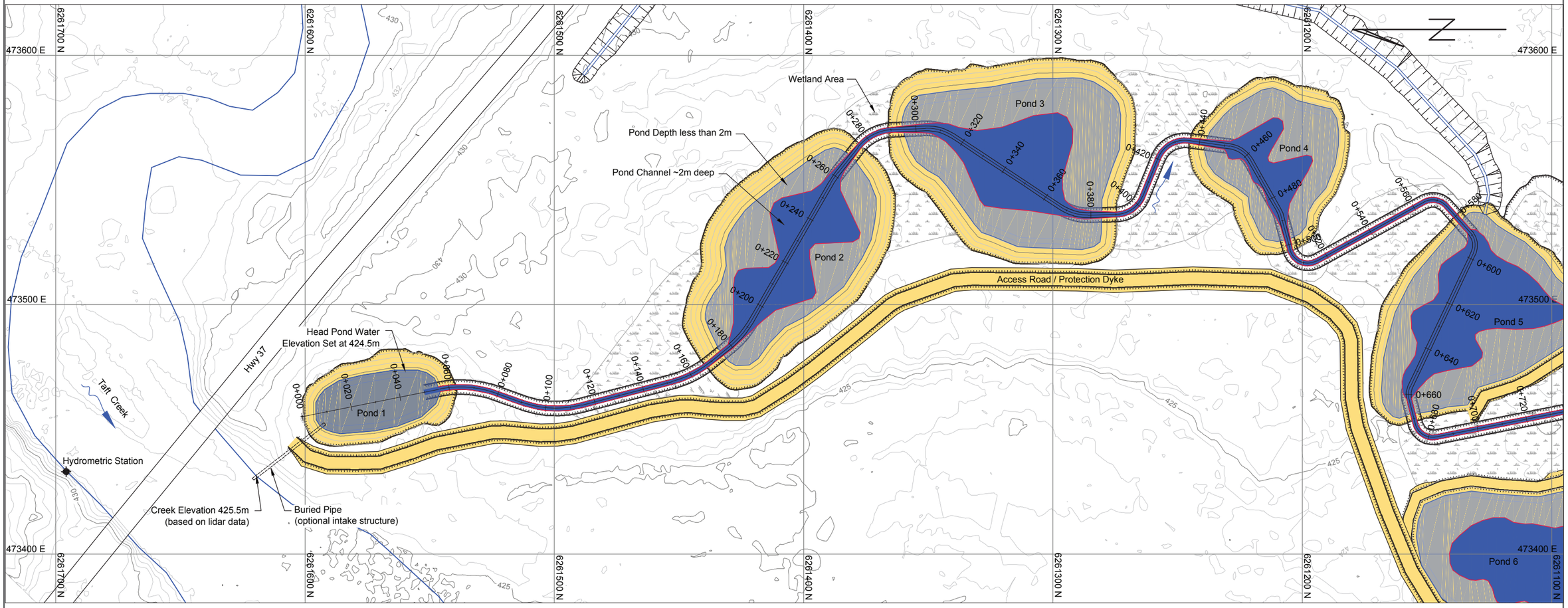

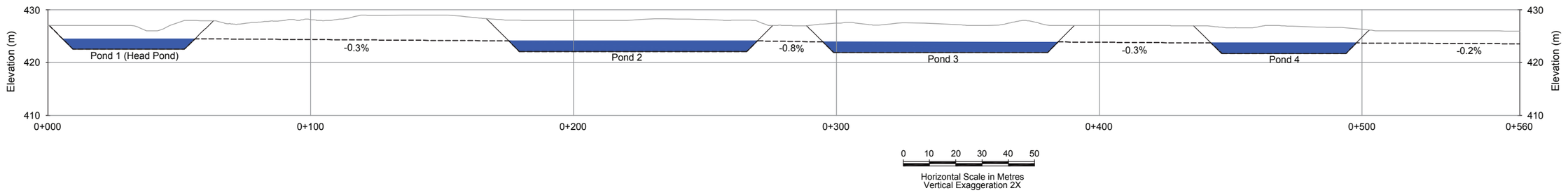

Figure 6.3-8a

Taft Creek Site 1 - Plan and Profile View (Station 0+000 to 0+560)

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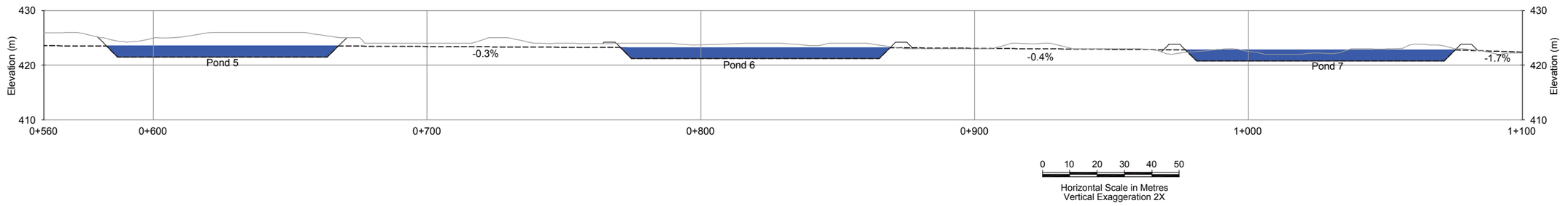

Figure 6.3-8b

Taft Creek Site 1 - Plan and Profile View (Station 0+560 to 1+100)

SEABRIDGE GOLD KSM PROJECT

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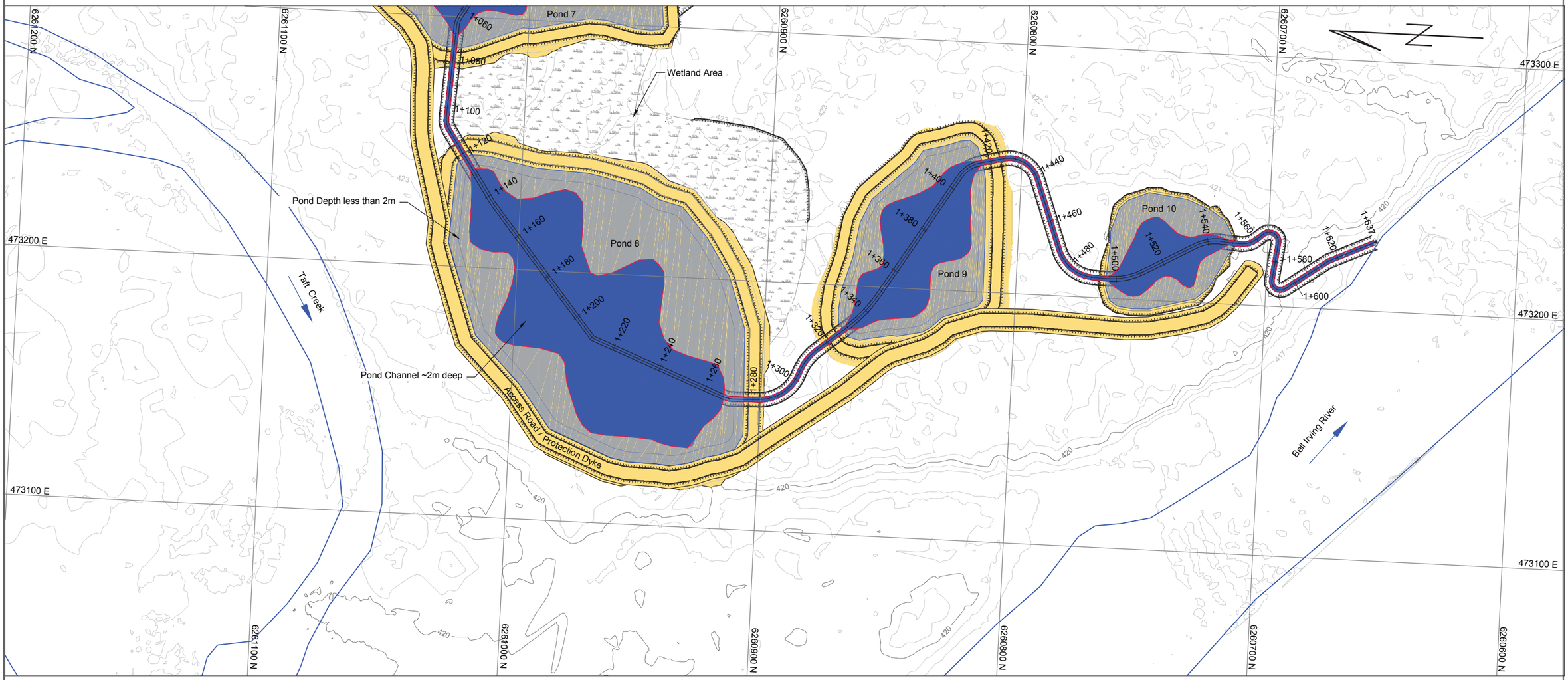

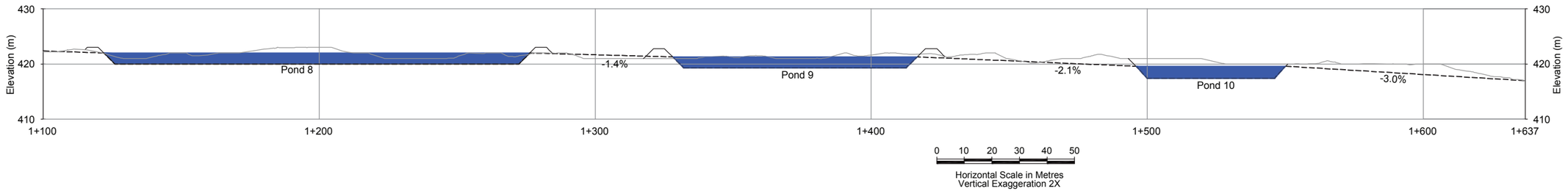

Figure 6.3-8c

Taft Creek Site 1 - Plan and Profile View (Station 1+100 to 1+637)

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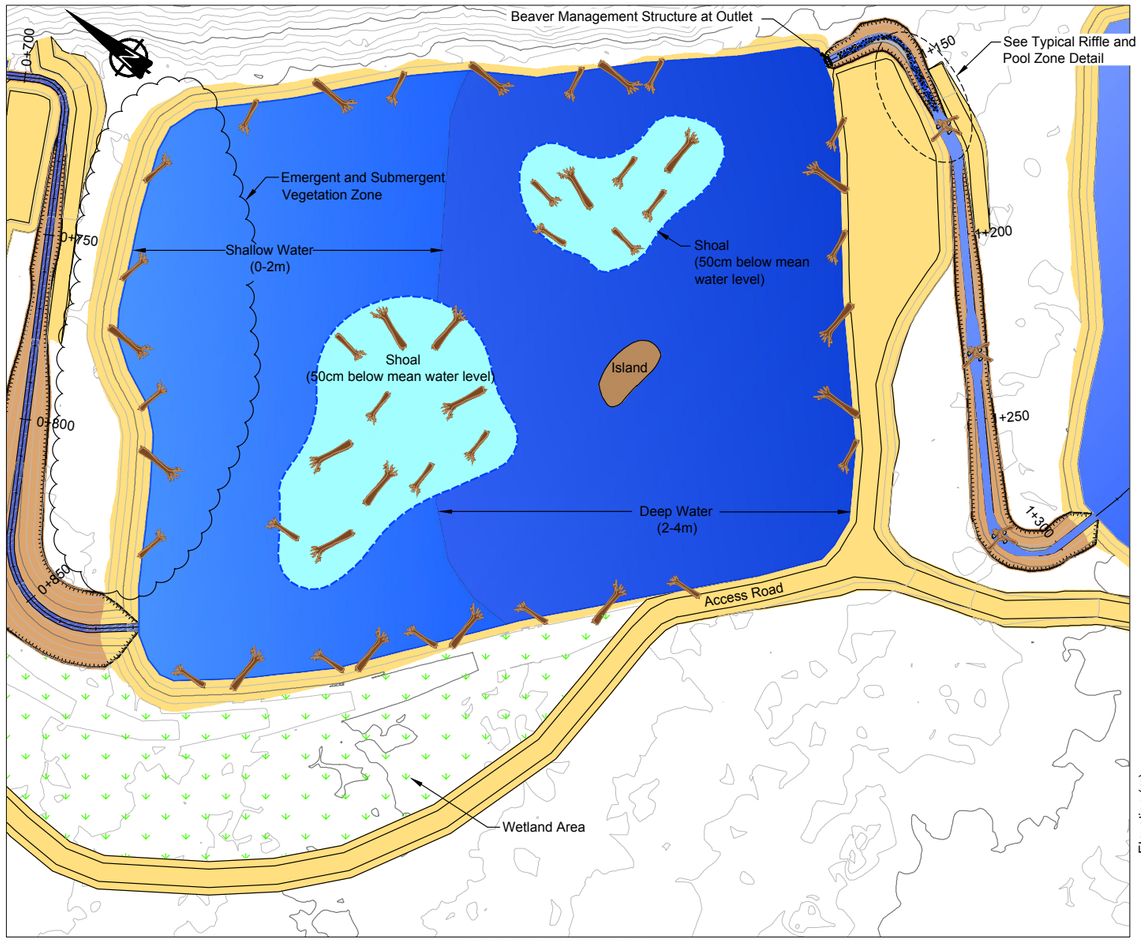
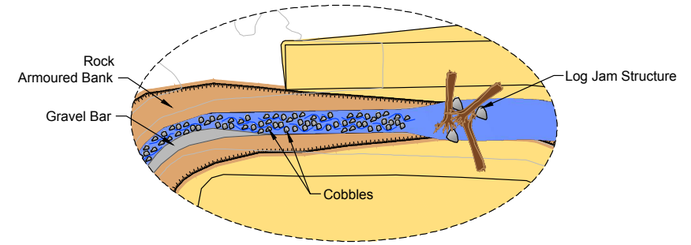


TYPICAL POND LAYOUT

0 5 10 15 20 25

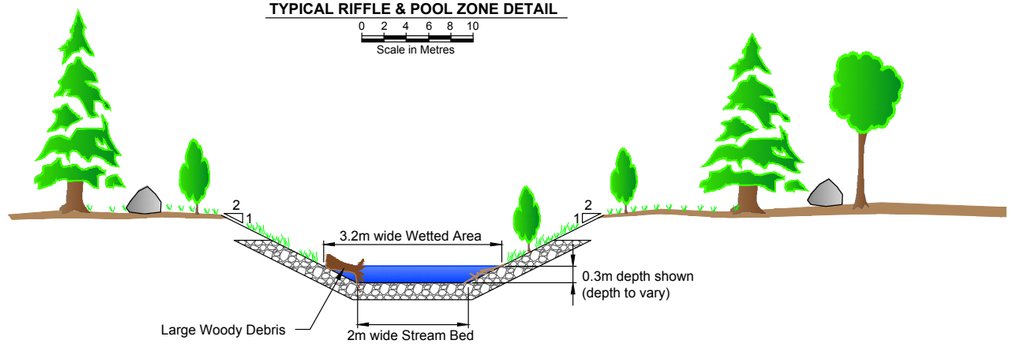
Scale in Metres



TYPICAL RIFFLE & POOL ZONE DETAIL

0 2 4 6 8 10

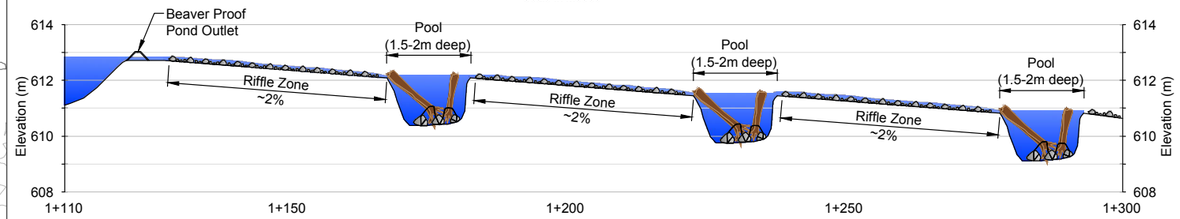
Scale in Metres



TYPICAL RUN ZONE CHANNEL SECTION

0 0.5 1 1.5 2 2.5

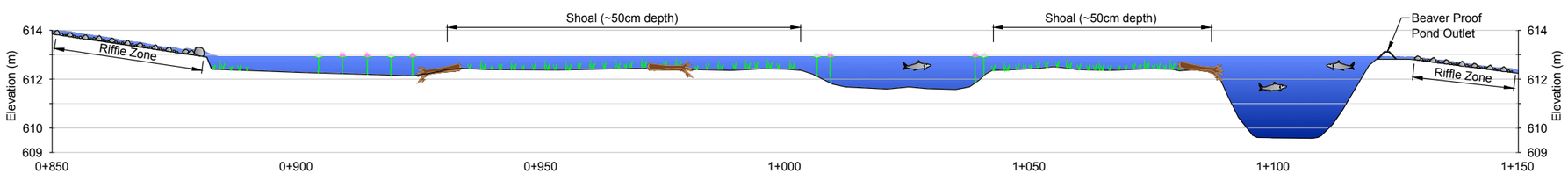
Scale in Metres



TYPICAL CHANNEL PROFILE

0 5 10 15 20 25

Horizontal Scale in Metres
Vertical Exaggeration 5X



TYPICAL POND PROFILE

0 5 10 15 20 25

Horizontal Scale in Metres
Vertical Exaggeration 5X

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Figure 6.3-8d

Taft Creek Site 1 - Pond and Channel Typical Plan and Sections

The channels will provide high quality rearing habitat for juvenile coho and Dolly Varden during the ice-free period. The pools in the channels will supply overwintering habitat in addition to the large ponds. The typical pond and channel layout and cross-sections are shown in Figures 6.1-1 to 6.1-3. Final channel dimensions and layout will be shown on construction drawings.

The typical wetted width of the channel will be 2 m wide and the channel incision will be 1.5 to 3 m deep. Water depth in channels will depend on slope and will range from 0.05 to 0.3 m (excluding pool depth). The channel will be complexed with salvaged materials (i.e., cobble, boulders, LWD, and root wads) such that approximately 50% of the channel has overhead or instream cover. Logs and root wads will be partially buried in the bank or cabled to boulders for stability (additional details on anchoring of LWD is presented in Section 6.1). The typical channel arrangement and details are shown in Figure 6.1-3.

Small pools will be excavated along the constructed channels every 20 to 30 m (Figure 6.1-1). Typical pools will be designed to have 1 m residual depth. They will be complexed with wood, branches, and boulders to provide cover. The gravel tailouts of pools will provide spawning habitat for the target species.

The channel will be sinuous with riffle/run/pool morphology and gradients from 0.5 to 2% (Figures 6.3-7 and 6.3-8 [a to c]). The channel will carry water from the Taft Creek intake at 592 masl at the highway crossing to the Bell-Irving River outlet at 419 masl. Excavated material will be deposited alongside the channel to form a tote road. The working corridor will be 15 to 20 m wide. Site preparation work prior to excavation will include tree felling and root wad grubbing; trees and root wads will be incorporated as fish habitat features within the channel.

The key elements of this channel will be the groundwater fed channel and the surface intake from Taft Creek (if required) and the outlet into the Bell-Irving River. This intake will be piped from the highway bridge crossing into the protected off-channel. The withdrawal amount will be determined based upon flow monitoring in Taft Creek and design volumes for the channels. The protected off-channel complex will be situated on a gravel terrace with mature coniferous forest (Figure 6.3-6). The terrace has adequate space to fit a series of ponds. It gradually drops in elevation down to the same elevation as the floodplain of Taft Creek.

The existing flood channel in the lower 50 m of the site becomes seasonally backwatered during freshet in the Bell-Irving River. The most downstream proposed pond in this complex will not be situated close to the Bell-Irving River to be protected by backwatering.

Ten bermed and excavated ponds will be constructed. The constructed ponds will range from approximately 0.10 to 1.08 ha and will be up to 4 m deep (Figures 6.1-1, 6.1-2, and 6.3-7). Each pond will be fit to the local topography and existing aquatic features, and fish will be salvaged prior to construction (e.g., sedges, wood, etc.). Beaver fencing and beaver structures (e.g., wood accumulations) will be built to prevent channel blockage and damage.

Highway 37 provides excellent access for heavy equipment and crews. An excavator, bulldozer, and several dump trucks will be required for construction, and small tote roads on excavated dikes will ensure easy access.

6.3.9 Habitat Gain Summary

Tables 6.3-3 and 6.3-4 summarize stream and wetland habitat gain for the compensation site. A coho salmon stream HSI was used for HU calculation because coho are the primary target species. A total of 83,986 HUs and 46,609 m^2 will be gained from this site.

Table 6.3-3. Taft Creek Site 1: Stream Habitat Creation Summary

Altered or Created	Area (m^2)	Coho Salmon Stream Habitat								Total HU
		Adult		Spawning		Rearing		Overwintering		
		HS	HU	HS	HU	HS	HU	HS	HU	
Created	1,936	0.75	1,452	0.75	1,452	0.75	1,452	0.75	1,452	5,808
Total	**1,936**									**5,808**

Table 6.3-4. Taft Creek - Site 1: Wetland Habitat Creation Summary

Altered or Created	Area (m^2)	Wetland Habitat				Total HU
		Rearing		Overwintering		
		HS	HU	HS	HU	
Created	44,673	1	44,673	0.75	33,505	78,178
Total	**44,673**					**78,178**

7. Summary of Habitat Losses and Gains

A total area of 89,620 m^2 (8.96 ha) of fish habitat will be lost from South Teigen and North Treaty watersheds due tothe deposit of deleterious substances into the proposed TMF and seepage collection ponds. This represents a total of 153,982 HUs (Table 7-1).

Table 7-1. MMER Compensation Plan Habitat Budget Summary

Habitat Loss		Habitat Gain						Compensation Ratio Achieved (Gained:Lost)	
		Treaty Creek Site 1		Taft Creek Site 1		Combined Sites			
Area (m2)	HU	Area (m2)	HU	Area (m2)	HU	Area (m2)	HU	Area	HU
89,620	153,982	153,567	279,403	46,609	83,986	200,176	363,389	2.2:1	2.4:1

A total area of 200,176 m^2 (20.2 ha) of fish habitat will be created as a result of the two proposed technically feasible compensation projects. This area represents a total of 363,389 HUs.

The ratio of compensatory habitat area to lost habitat area is 2.2:1. The ratio of compensatory HUs to lost habitat units is 2.4:1, which is greater than the minimum 2:1 ratio typically requested by DFO. Therefore, the requirements to compensate for project related fish habitat loss has been effectively achieved. However, when fish habitat compensation construction proceeds, projects will be built according to a ratio of compensatory HUs to lost HUs of 2:1.

8. Construction Management

8.1 CONSTRUCTION PLANNING AND TECHNIQUES

The technically feasible compensation projects will undergo final design development prior to construction. The proposed compensation sites are adjacent to or within fish-bearing streams and wetlands, consequently the construction must be implemented safely and effectively to avoid adverse effects. Implementation of the as built designs will involve construction planning, site preparation, design layout, mobilization of equipment and materials, on-site construction, and demobilization. Management and mitigation of risks and potential adverse effects to existing fish and fish habitat will be critical to the success of the compensation projects. These potential effects include:

- increased sedimentation or dewatering of fish habitat;
- contamination as the result of hazardous substance spills;
- loss or alteration of fish habitat;
- alteration of water and/or sediment quality; and
- alteration of the productive capacity of aquatic habitat.

A Fish and Aquatic Habitat Protection and Mitigation Plan has been developed for the environmental assessment process for construction. The plan will guide similar activities that will be carried out for construction of compensation sites to prevent impacts (Rescan 2012d).

The implementation and construction stages of the Plan are summarized below including the type of activity and the risks they present to fish habitat. In addition to those measures listed in the Fish and Aquatic Habitat Protection and Mitigation Plan, mitigation measures are summarized in Section 8.2. The construction process will include the following components:

- Layout and site marking will include minor brush clearing and staking of the excavation boundaries for channel and pond arrangements. Crews will undertake danger tree assessment, identify fuel handling and fish salvage locations, and flag access routes, laydown areas, no disturbance and machine-free zones, temporary stockpile locations, etc. This step poses no risk to fish habitat as no heavy equipment is involved.
- Heavy equipment will either be trucked to access points along existing roads or disassembled and flown into staging areas at remote sites. Airlifting of heavy equipment (e.g. excavator, bulldozer, and spider-hoe) into remote compensation sites will require laydown areas for equipment assembly. Generally, existing openings at least 50 m away from aquatic habitat will be used such that no risk is posed to fish habitat from accidents or spills during re-assembly.
- Temporary access (i.e., tote roads or trails) will be developed at compensation sites with minimal effect on riparian vegetation and fish habitat. Streams will be crossed with temporary structures (e.g., log box) built with on-site materials. Temporary fording of some channels will be required for initial access but only across stable channels with competent banks. Generally, excavated materials from channels and ponds will be spoiled into dikes for use as tote roads. Tote and access roads will be kept narrow (5 to 7 m wide) and avoid sensitive features. Risks to fish habitat along tote roads will be minimized by avoiding aquatic features as much as possible and preventing sedimentation. Temporary access routes will be re-vegetated upon completion to prevent erosion and sedimentation of aquatic habitat.

- Vegetation clearing and tree felling will be conducted by hand in sensitive areas or with heavy equipment in non-sensitive areas (e.g., dry areas). It will involve minimal felling into or over existing fish habitat as most can be felled away. Clearing of trunks and root wads will be done with an excavator, and LWD will be used in ponds and channels for complexing.
- Ponds and channels will be dug by medium to large excavators, and a bulldozer will assist with creating berms at backwatered ponds. Dump trucks will be used at road accessible sites. Equipment will be leak-free, well-maintained and, where needed for instream work, will use biodegradable hydraulic fluids. Sedimentation risks to existing fish habitat from excavation will be managed by isolating work sites, constructing temporary diversions for clean stream flow through sites or installation of sediment control features (e.g., sumps and pumps).
- Logs and boulders will be salvaged from pond and channel footprints or transported into sites by truck or helicopter. Materials sourced from outside the footprint of ponds and channels will come from other areas not situated near aquatic habitat (e.g., hillside wood will be transported by helicopter for instream structures).
- Extensive instream construction is planned and will require heavy equipment (e.g., spider-hoe, excavator) for working in wet and dry stream channels. A spider-hoe is a specialized excavator with wheels and posts instead of tracks and has minimal footprint. This equipment has been used extensively for instream restoration throughout BC.
- Some existing beaver ponds and channels containing fish and fish habitat will be drained or modified to fit much larger compensation features at the same location. Fish will be salvaged from ponds. Fish will be released in the nearest similar habitat type while vegetation will be stockpiled for re-introduction to compensatory habitat. Water levels will be drained slowly to prevent downstream impacts and ensure a complete fish salvage.
- Environmental monitoring and continuous supervision will be essential for the successful completion of the compensation sites.
- A re-vegetation plan (Section 8.3) will be implemented as soon as construction activity is completed. The re-vegetation plan will include seeding and planting with approved plants and grasses to restore ground cover, stabilize soils, minimize sedimentation and promote riparian function at all compensation sites.

8.2 MITIGATION MEASURES

8.2.1 Standard Operating Procedures

Relevant standard operating procedures will be followed in all habitat compensation projects. Pertinent legislation includes the *Water Act* (1996), the *Fisheries Act* (1985), and the *Species at Risk Act* (2002). The principles outlined in these and all other relevant federal and provincial enactments will be incorporated in the planning and implementation of all compensation activities. Appropriate permits and approvals will be acquired prior to beginning construction.

Qualified individuals familiar with standard operating procedures will direct and plan the work in order to maintain compliance with the standard operating procedures.

8.2.2 Best Management Practices for Instream Works

Best management practices (BMPs) will be followed during the construction and maintenance of the compensation projects. Compensation activities will be planned to avoid or minimize the adverse effects of these activities and to prevent long term deleterious effects. Qualified professionals will manage the design, implementation, and monitoring of these activities to ensure the protection of

habitat and the implementation of BMPs. The general techniques, based on *Standards and Best Practices for Instream Work* (BC MWLAP 2004), *Fish Stream Crossing Guidebook* (BC MOF 2002), and *Riparian Revegetation* (DFO 2000), to be used during construction include:

- keeping machinery clean and preventing fuel leaks or spills;
- delineating work site boundaries and confining disruptive work to within those boundaries;
- designing access routes to minimize disturbance to existing habitat and vegetation;
- performing any in-water work to periods of least risk to fish;
- installing sediment control mechanisms where earth works are to take place; and
- minimizing disturbance to riparian vegetation and seeding and/or replanting riparian areas where vegetation is disturbed.

Additional mitigation measures that may be used during compensation works are detailed below. During the detailed planning stage, site-specific management plans will be created based on the specific construction plan and features of each site.

8.2.3 Site Access

Compensation sites will be accessed via helicopter and/or constructed access roads. Access plans will be made with consideration for individual site characteristics, minimization of environmental impact, and feasibility.

Access by helicopter will require the construction of helicopter landing sites, possibly requiring the clearing of trees and vegetation. The location of these sites will be chosen so that their clearing and use will not have significant adverse effects on bank stability and erosion.

Routes for temporary access roads will also be planned to minimize environmental disturbance. Where possible, crossing fish-bearing streams will be avoided. Where stream crossings are necessary, riparian disturbance will be minimized and fish passage will be provided (BC MOF 2002).

8.2.4 Vegetation Clearing

Trees and vegetation may be cleared during the construction of access roads, helicopter landing sites, stream access points, and refueling and construction zones. Additional clearing may take place during the excavation of new ponds or channels. Grubbing will be minimized, but is likely to occur in excavation projects. In compliance with WorkSafeBC policies, a dangerous tree assessment will take place in the construction area prior to beginning work. The dangerous tree assessment may require the removal of additional trees in the construction area. The effect of these activities on the environment will be mitigated with the following measures:

- trees to be removed, by permits, will be identified individually and will only be removed if it is deemed necessary;
- trees will be felled so that they do not enter the stream channel;
- trees and rootwads removed during construction will be used to build habitat complexity in the enhancement projects;
- work in compensation areas will use the minimum number of access points necessary, and locate them such as to avoid particularly sensitive areas of vegetation or areas where bank stability would be significantly affected (BC MWLAP 2004);

- where possible, machinery that must move down the stream may move along dry portions of the creek bed to avoid damaging vegetation; and
- damaged areas will be revegetated using vegetation salvaged from excavation areas whenever possible, or otherwise replanted and/or seeded with approved vegetation from other sources.

8.2.5 Sediment and Erosion Control Measures

Sediment mobilization and increased erosion are possible risks of construction in stream areas. Construction plans will be designed to maintain bank stability and mitigate or repair any damage caused by compensation work. To control and minimize the sediment mobilization and bank erosion, control measures that may be taken include:

- using water diversion structures to divert dirty water from the work zone to a sediment control area;
- installing silt fencing, geotextile cloth, hay bales, berms, or other sediment control structures;
- conducting instream work from the point farthest away from the access point and working backwards;
- allowing constructed ponds to settle before connecting to the stream;
- storing soil, substrate, removed vegetation and building materials in stable areas away from the channel;
- ensuring that all rock materials used in the stream are inert;
- placing introduced cover structures so that they will not result in unstable or eroding banks;
- ensuring constructed banks are graded at a stable slope; and
- stabilizing excavated materials and areas denuded of vegetation using temporary erosion control blankets, biodegradable mats, planted vegetation, or other erosion control techniques.

A response plan will be created to detail sediment and erosion control measures to be taken in the event of an unexpected increase in overland runoff or saturation of the work area due to precipitation. Additional measures will also be taken in the event that construction monitoring identifies a failure or potential failure of existing sediment control structures.

8.2.6 Fuel Management

The input of fuel or other deleterious substances to the stream will be prevented. Steps to be taken to prevent the occurrence of a spill include:

- inspection of all equipment and machinery prior to and during all work to ensure that it is clean and free of leaks;
- the use of environmentally-friendly hydraulic fluid and fuels in all heavy machinery to be used near/within watercourses;
- placement of drip pans and spill pads underneath pumps or other stationary machinery; and
- provision of readily-accessible spill kits in all areas where machinery or fuel tanks will be used, stored, or refueled, and training of personnel in their use prior to beginning construction.

A Spill Response Plan will be created that will detail the steps to be taken to properly contain, clean up, and report any spills that may take place. To ensure a rapid response to leaks and spills all construction personnel will be trained in the procedures outlined in the Spill Response Plan.

8.2.7 Waste Management

All waste and excess material created or imported for the compensation projects will be stored and removed to avoid causing environmental harm. Examples of potential waste management include:

- developing protocols for waste reduction, reuse, and recycling during construction;
- storing soil excavated during construction on a stable surface outside of the stream channel and covered or contained by erosion control structures or replanted vegetation;
- managing vegetation removed from the work zone by either storing for salvage and replanting or piling away from the stream banks for storage or burning; and
- removing non-biodegradable materials brought into the site including sediment control structures, equipment, and supplies (BC MWLAP 2002).

8.2.8 Water Management

Should water diversion be required, coffer dams, pumps, or other approved water-diversion methods may be used to temporarily divert water around the construction zone while still maintaining flow downstream. Dirty water will be pumped to a sediment control area where the sediment can settle or be removed before returning to the stream (BC MWLAP 2002). Backup pumps may be kept on site in case of mechanical failure.

As a part of enhancement activities, beaver ponds and other areas of standing water may be drained. Where draining of wetted areas occurs, measures will be taken to ensure that the process will not cause erosion of stream banks or terrestrial areas.

8.2.9 Fish Salvage

Prior to dewatering small ponds or streams, fish will be salvaged and removed from the site. As part of the fish salvage and exclusion process, the following steps will be taken to minimize disturbance:

- the pond or stream will be isolated using seine nets;
- passive or active capture techniques, or a combination of the two, will be chosen based on characteristics of the site and used to capture fish;
- fish will be immediately removed to recovery buckets; and
- post-recovery fish will be moved to the suitable habitat nearest the salvage site.

In larger mainstem areas where isolation and salvage would be difficult, the site will not be sectioned with nets. Instead, electrofishing will be used to encourage fish to move from the immediate area immediately prior to any instream works.

8.2.10 Rare Species and Ecosystems

To mitigate for western toad habitat loss at compensation sites with potential/confirmed toad habitat, the following measures will be implemented in the Design and Construction phases of the projects:

- create ponds with shallow areas that maintain solar radiation of the ponds, allowing for suitable toad larval rearing habitat;
- create ponds with deep areas that increase the hydroperiod of the ponds to maintain pond habitat throughout the breeding and larval development stages;
- plant emergent aquatic vegetation within pond;
- create mudflats along the pond margins to provide breeding habitat; and
- construct compensation projects that will adhere to western toad breeding and rearing timing windows (i.e., mid-May to early September) within toad habitat.

To mitigate for rare ecosystem habitat alteration and/or loss at compensation sites with rare ecosystems, the following measures will be implemented in the Design and Construction phases of the projects:

- develop prescriptions to avoid or minimize degradation to rare ecosystems at a spatial and temporal scale prior to construction (including providing a clear definition of degradation, and methodology on how to measure it);
- assess the historical range of variability at the compensation site (e.g. frequency and magnitude of flood events, and evidence of late seral, longitudinal and vertical movement of the river) relevant to the reference ecosystem. Assessing this variability will involve an analysis of both soil and vegetation characteristics, as well as channel morphology.
- design off-channel complexes to simulate natural conditions through seasonal flooding.
- ensure clearing activities are coordinated with other timing restrictions for wildlife and fish;
- conduct a rare plant survey prior to construction to identify and relocate plants. Where feasible, seeds or seed capsules will be collected and retained for future restoration efforts;
- consult the *Windthrow Handbook for British Columbia Forests* (Stathers, Rollerson, and Mitchell 1994) for guidance in assessing windthrow risk and for developing prescriptions to reduce the risk;
- minimize clearing dimensions (regardless of clearing size or ecosystem affected);
- manage construction spoil to not affect identified rare ecosystems;
- adopt low disturbance methods to clear vegetation within identified sensitive areas, where clearing cannot be avoided. In such areas, vegetation maintenance and removal techniques such as pruning, mowing, girdling, topping and select tree removals allow root systems to remain intact, help bind the soil and encourage rapid colonization of low-growing plant species (BC MOE 2010b);
- re-vegetate using vegetation salvaged from excavation areas whenever possible and/or seed in accordance with the Surface Erosion and Sediment Control Plan.
- preferentially retain mature and old trees (older than 80 years), where the option exists to remove younger stands;
- establish performance indicators that will be used to determine whether particular elements of the Plan are being implemented to evaluate how successful effects to listed ecosystems are being levitated; and
- review and summarize monitoring output and make adjustments, if necessary.

8.2.11 Construction Monitoring and Inspections

Throughout the access development and construction processes, a qualified environmental professional familiar with BMP will be present (BC MWLAP 2004). As part of his or her onsite activities, he or she will:

- oversee all work;
- inspect structures and activities;
- be provided with the authority to modify or halt any activity if he or she deems it necessary to protect fish, habitat, wildlife, or safety; and
- consult with the construction manager to ensure that all activities follow BMP.

Following the completion of the Construction Phase, the compensation works will be monitored according to a monitoring plan.

8.3 RE-VEGETATION MANAGEMENT PLAN

8.3.1 Overview

Fish habitat compensation will involve the disturbance and removal of existing vegetation at compensation sites. Vegetation disturbance and removal can expose soils (leading to potential soil erosion), change light regimes (allowing for colonization by invasive species) and disrupt riparian function. In order to both achieve the objectives of fish compensation and mitigate loss of other ecological functions, impacts to what are often pristine sites must be minimized.

The objectives of the Re-vegetation Management plan are to:

- stabilize soils to minimize potential for erosion and sedimentation; and
- promote, to the maximum extent possible, the restoration of diverse ecological functions at all compensation sites.

The Plan will be implemented as soon as construction activity is underway. Site-specific details will be developed and refined once the full extent of disturbance and loss of native vegetation cover, including dominant species, is known. These site specific plans will be developed by a qualified professional and will identify the methods for soil stabilization, vegetation salvage, species selection, timing, storage needs, and planting techniques. The re-vegetation plan will be driven by the scheduling of both mine and compensation site construction to maximize the efficiency of salvage and transplant operations and minimize soil and vegetation exposure.

Mitigation measures, detailed within the Fish and Aquatic Habitat Protection and Mitigation Plan (Chapter 26.18.1), will be adopted for all re-vegetation activities. These include specific measures pertaining to:

- standard operating procedures, which adhere to pertinent Provincial and Federal legislation, such as the *Water Act* (1996), *Fisheries Act* (1985) and the *Species at Risk Act* (2002);
- best management practices for instream works;
- site access;
- vegetation clearing;

- soil management (including mitigation of degrading practices such as compaction and rutting);
- sediment and erosion control measures;
- fuel management;
- waste management;
- water management;
- rare species (including western toad) and ecosystems; and
- construction monitoring and inspections.

Additional information guiding site-specific management activities may be incorporated from the Forest Practices Code Soil Rehabilitation Guidebook (MOF 1995). As described in this guidebook, re-vegetation represents a fundamental process in the rehabilitation process and may be conducted using a variety of techniques depending upon the specific site objectives. This guidebook presents a variety of techniques and solutions to be considered within the rehabilitation plans for re-vegetation of disturbances from:

- landings;
- roads and roadsides;
- excavated and bladed trails;
- compacted logging trails;
- ruts and areas of dispersed disturbance;
- gravel and rock pits; and
- landslides.

In addition to the above mitigation, additional information to incorporate in the development of a site-specific re-vegetation management plan may be incorporated from the following existing KSM Project management plans:

- **Wetlands Management Plan** (Chapter 26.19) - The primary objective of this Plan is to minimize effects on wetlands through implementing targeted activities, monitoring, and adaptive management.
- **Vegetation Clearing Management** Plan (Chapter 26.20.2) - The primary objective of this Plan is to minimize the effects of vegetation clearing and degradation (secondary vegetation loss and disturbance) linked to clearing activities. Mitigating the loss of ecosystem function is of critical importance. Ecosystem functions include habitat, hydrological, water quality, and soil stability functions.
- **Invasive Plant Management Plan** (Chapter 26.20.2) - The primary objectives of this Plan are to minimize the creation of suitable habitat for invasive plant species (with emphasis on the NWIPC priority plant species) and minimize the opportunity for invasive plant seeds or reproductive material to be transported into the site. It will draw upon the Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia (BC MOFR 2010), which outlines an integrated pest management (IPM) approach for invasive alien plants, under the authority of several partnering ministries. The implementation of an IPM approach is also a recommended strategy of the NWIPC (2011).

- **Wildlife Management Plan** (Chapter 26.21) - The overall objectives of the Wildlife and Wildlife Habitat Management Plan are to minimize wildlife mortality as a direct consequence of the Project; and to avoid any adverse effects on protected species, their habitats, or breeding and feeding activities.
- **Erosion Control Plan** (Chapter 26.13) - The primary objective of this Plan is the prevention of soil erosion throughout all phases of the Project. As vegetation cover plays a vital role in erosion control, areas where vegetation has been temporarily removed will be re-vegetated with an appropriate seed mix as soon as possible. Additional means of soil surface stabilization will be used while the vegetation is established where required.

8.3.2 Site Review and Re-vegetation Objectives

The site review process involves an inventory of the vegetated ecosystems present within the proposed compensation site, prior to construction works. This allows for the documentation of species assemblages which in turn inform what ecological functions are performed at the site in its pre-disturbance state. The review phase is critical to project success; by documenting what ecological functions are present, reasonable and achievable objectives can be met for re-vegetation for the overall objective of restoring ecological function. This must be done within the limitations imbued to site as a consequence of fish habitat compensation work, the construction and maintenance of which will, in certain cases, mitigate the reestablishment of previously existing ecosystems.

Re-vegetation objectives will therefore be determined by the site review, the type disturbance associated with compensation efforts, and by the expected limitations imposed on the site after compensation features have been established. A like-for-like ecosystem restoration target will not necessarily be promoted, as it may very well not be ecologically feasible. Ecological seral development can result in alternate steady states. While many factors are involved, the type and duration of disturbance plays an important role in what path seral development follows. For example, fish compensation sites will, in many instances, alter local hydrology. This will permanently (or as long as the compensation structures are in place) alter the soil moisture regime in the associated riparian areas, which will affect which plant assemblages are dominant. Therefore, managing for the return of the pre-existing plant community will be a tenuous undertaking.

8.3.3 Selection of Re-vegetation Techniques

The purpose of the Re-vegetation Management Plan is to establish vegetative ground cover to retain ecosystem function and to avoid soil loss and erosion at compensation sites. Detailed plans will be created in order to consider the on-the-ground conditions post-disturbance. These will be site specific. Activities associated with the re-vegetation plan include the following:

1. Determine the future characteristics (soil depth, soil nutrient potential, likely plant species and relative dominance, light regimes during development and maturity) and functions (productivity, hydrologic function, biodiversity, habitat) of the disturbed site in order to determine which type of plant communities should be managed for.
2. Identify appropriate re-vegetation species in consultation with relevant experts that is determined by the following:
   - Biogeoclimatic ecosystem classification (BEC) unit;
   - baseline species assemblage;
   - elevation;
   - terrain type;
   - soil type;

- time of planting;
- local weather trends (e.g. dry year versus wet year);
- slope location (lower bank, mid bank, upper bank); and
- disturbance type and intensity.

3. Prepare the site based on the identified end use objective using standard best management practices outlined in the Forest Practices Code Soil Rehabilitation Handbook and in accordance with the Department of Fisheries and Oceans Riparian Areas and Re-vegetation guidance (2000). Site preparation may be altered based on local ecological site requirements. Existing native vegetation will be retained wherever practical, including protection of trunk, limbs and roots from damage through use of machinery;
4. Re-vegetate the site based on standard best management practices outlined in the Forest Practices Code Soil Rehabilitation Handbook. These will include:
   - no planting within shallow open water wetland areas with water depths > 50 cm.
   - shallow emergent vegetation along slopes of less than 3:1 run:rise in areas with less than 50 cm of water depth (seeding and potential cuttings).
   - designated tree planting on elevated berms or mounds throughout the shallow swamp wetland areas (planting of selected seedlings and saplings in specific areas and densities).
   - adjacent forested wetland transition zones (seeding, planting of saplings, and cuttings in selected areas based on the flood or drought tolerance of selected species). Planting will use a combination of seedlings, cuttings and salvaged materials at each site.
5. adjacent upland areas within the wetland buffer that have been disturbed by restoration activities (open soil stabilized against erosion and planting of native sapling and seedling species that replicates the existing stand and shrub structure of the pre-compensation habitat).

8.3.4 Implementation of Re-vegetation Works

While the specific issues, site objectives and disturbance extent and severity may dictate the technique to be used, two re-vegetation techniques commonly used in restoration activities include dormant cuttings and transplants (Babakaiff, Hay, and Fromuth 1997).

Dormant cuttings are used in restoration projects in a variety of ways, including live staking, brush layering, live siltation, brush mats, and bundles (fascines). Dormant cuttings can be harvested from living, woody plants during the winter/early spring (or during the fall if planting will occur in the fall) or purchased from nurseries. Cuttings are collected from plant species that root easily, such as willow, poplar, and cottonwood. Live staking is often used in conjunction with other re-vegetation techniques and is an inexpensive method of re-vegetating a site. It does, however, have a lower survival rate when compared to other re-vegetation techniques. Brush mats constructed of dormant branches provide both erosion control and vegetative cover to an area. They require large amounts of plant material, which will be considered prior to their inclusion in a re-vegetation design.

Transplanting involves the relocation of a plant or plants containing roots and shoots from one area to another. Transplants can vary in size, from large vegetation mats to smaller plugs, sprigs, and single-plant transplants. All types of transplants require careful handling in order to ensure success. Transplanting can be mechanized, depending on the size of material (e.g., vegetation mats). Transplanting is a suitable re-vegetation method used for species that do not root well from cuttings.

Vegetation mats can also be propagated in a greenhouse or outdoors. The benefit of vegetation mats is that they provide an instant plant cover and also help protect the site from soil erosion.

If the introduction of herbaceous vegetation to the area is a desired goal, then the use of a vegetation mat composed of native grasses or sedges will be considered. Similarly, grass and sedge species can be fashioned into a roll, held together with biodegradable fabric and twine (Babakaiff, Hay, and Fromuth 1997). When placed along the bank, the roll provides structural protection as well as an overhanging vegetative cover. Plugs and sprigs are smaller than vegetative mats and often contain only one plant species. They can be collected from a donor location or can be grown in a nursery or greenhouse environment.

8.3.5 Seed Mixes and Plant Species Selection

Target plant species can be those used to either stabilize soil and prevent soil erosion, or to attempt to initiate an ecological seral trajectory. The first priority will be to prevent the loss of the soil resource, as all other restoration objectives are dependent on soil availability.

Where seeding represents the preferred rehabilitation option, an approved seed mix for low elevations will be developed for the fish habitat compensation sites in consultation with local seed source suppliers and/or other experts such as local Ministry Agrologists. Where possible, a locally-sourced mix will be selected based on the detailed site information that will be provided to the seed distributor. Such detailed site information will include the following:

- Project region;
- current provincial biogeoclimatic ecosystem classification (BEC) unit (i.e. Very Wet Cold Interior Cedar Hemlock Subzone, ICHvc) and baseline species assemblage;
- disturbance elevation (or elevation range); and
- disturbance type and intensity.

The types of plants used to re-establish ecological function will be entirely site specific: specification is beyond the scope of this plan. However, plant salvage at the site will be a priority.

8.4 PROPOSED SCHEDULE

The compensation project planning and completion will be composed of six phases: Detailed Design Assessment, Detailed Design Planning, Permitting, Second Year Fisheries Monitoring Assessment, Pre-construction Planning, and Construction (Table 8.3-1). Construction is tentatively scheduled after the permit approval process and within one year after commencement of construction of the KSM Project, but will be subject to changes based on the KSM Project schedule.

Table 8.3-1. Proposed Compensation Schedule

	2012				2013				2014				~ 1 Year of Project Construction			
Phase	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Detailed Design Assessment																
Detailed Design Plan																
Permitting																
2nd Year Fish Monitoring Assessment																
Pre-construction Planning																
Construction																

'Q' represents quarter of a year

During the Detailed Design Assessment Phase, the soils, hydrology, water quality, and groundwater influence in the proposed compensation sites will be assessed. Additional physical surveys will be conducted at Treaty Creek to further characterize the site's soils and groundwater.

The Detailed Design Assessment Phase will provide the necessary data for detailed design planning. During the detailed design planning phase, the physical site information will be used to develop construction plans for the selected sites. The detailed design plans will expand on previous technically feasible plans to include more specific project features and design drawings.

The Permitting Phase will involve identifying and applying for any necessary government tenures, permits and approvals. Permitting also includes EA and Section 35(2) *Fisheries Act* (1985) approvals. The Pre-construction and Construction phases will only be initiated once all permits and approvals are secured.

Additional fisheries assessment info will be collected to complement existing baseline studies. Fish and fish habitat information will be collected at the proposed compensation sites as needed. This baseline data will act as the basis for the post-construction intensive effectiveness monitoring (Section 9.2).

Logistical planning and organization for construction activities will take place during the Pre-construction Phase. Site access routes; construction schedules; and the organization of equipment, supplies and activities will be addressed during this phase, which will occur prior to and concurrently with the construction.

The Construction Phase will entail constructing physical works as per the specifications outlined in the constructions plans. The plans will be modified where necessary to ensure proper site function. Construction of compensation projects will be staged for effective project management. At the completion of this phase all compensation habitat will have been constructed and the full compensation area created.

After site construction is completed, post-construction monitoring will be carried out according to the plan detailed in Section 9.

8.5 TENURE AND ACCESS

All proposed compensation sites are on Crown Land (Integrated Land and Resource Registries 2010), and will not require permission from private landowners. Permits and authorizations required for this project will include:

- *Fisheries Act* (1985) Authorization to modify fish habitat;
- Water Licence for activities requiring water diversion;
- Ministry of Forests and Range Special Use Permit for construction of access roads;
- *Wildlife Act* (1996) Permit for projects requiring the disturbance of beavers and/or beaver dams;
- Fish Collection Permits from the BC MOE and DFO for salvage of freshwater and anadromous fish species respectively; and
- Licence to Cut from the BC MOF for the removal of trees in the construction of access roads and new fish habitat.

In addition, consultation with a Navigable Waters Protection Officer will be needed to determine whether approval will be required under the *Navigable Waters Protection Act* (1985). Other necessary permits or approvals may be identified during future compensation planning. All pertinent permits and authorizations will be acquired prior to beginning work.

9. Compliance and Effectiveness Monitoring

9.1 COMPLIANCE AND ROUTINE EFFECTIVENESS MONITORING

Post-construction compliance and routine effectiveness evaluation (REE) monitoring focuses on project integrity, compliance with approved designs, and biological effectiveness. Compliance and REE monitoring is primarily qualitative in nature, however quantitative data are collected. The primary methods include measurements and surveys, observation, and use of existing design documents (Pearson et al. 2005).

Compliance and REE monitoring will be conducted for all compensation projects. An as-built topographical survey will be completed in Year 1 following construction for all instream structure types (e.g., boulder clusters, LWD), to allow for construction materials to settle and allow for bed scour. A checklist for presence and integrity of important project elements will be developed and used to facilitate comparisons (BC MWLAP 2001). Photographic monitoring of important project features (e.g., inlet structures) will be taken.

To verify that a compensation project was implemented as designed and approved, a number of variables will be measured. These variables will include, but not be limited to the following (Pearson et al. 2005; Slaney 2006; BC MWLAP 2001):

- Area: Does the total area of habitat created or restored match that of the specifications of the approved design?
- Configuration: Does the spatial arrangement of habitat types correspond to the approved design?
- Materials: Are the materials used of the type and size specified in the approved design?
- Structural integrity: Are all structures (e.g., inlets, outlets, riffles, rootwads, etc.) in place and functioning as designed? Is there significant structural instability (e.g., erosion) on the site?

As habitat changes over time, additional post-project surveys will be conducted following construction in Years 2 and 5. Monitoring will involve rating of all projects as a four point scoring of performance (i.e., success to failure) in meeting both physical and biological project objectives, structural stability and condition, and maintenance needs (BC MWLAP 2001). Furthermore, informal visual inspections of structural integrity will be conducted as part of intensive effectiveness monitoring (Section 9.2). If a compensation project is not functioning optimally, then project changes and additional construction may be required.

The results of the compliance and REE monitoring will be provided to regulatory agencies, Aboriginal groups and other stakeholders.

9.2 INTENSIVE EFFECTIVENESS MONITORING

9.2.1 Experimental Design

The objectives of intensive effectiveness monitoring are similar to those of REE monitoring with the exception that measures of biological effectiveness are quantified, usually in terms of net change in habitat productive capacity. Intensive effectiveness monitoring focuses on quantitative experimental design and statistical analysis. Site effectiveness monitoring is typically applied to large and/or complex compensation projects (Pearson et al. 2005).

Site effectiveness monitoring will be conducted for all compensation projects. The approach to effectiveness monitoring will follow a Before After Control Impact (BACI) experimental design for sites with existing habitat to be enhanced (e.g., Treaty Creek Site 1). The approach to effectiveness monitoring will follow a post-treatment experimental design for sites that create new habitat because there is no baseline data with which to compare (e.g., Taft Creek Site 1). Two years of pre-construction monitoring data will be gathered to account for inter-annual variances in the BACI experimental design. Post-construction effectiveness monitoring will follow two, two year periods to allow for separate statistical testing in each of the two periods (Pearson et al. 2005):

- Short term - Years 1 and 2, and
- Medium term - Years 5 and 6.

After Year 6, compensation project effectiveness will be evaluated and the necessity of future monitoring will be determined.

To quantify a net change in habitat productive capacity multiple key performance criteria will be evaluated and will depend upon the project specific objectives, target habitats, fish species and life history stages (Section 9.2.2).

Control sites will be selected (one local and some distant) for compensation projects. This will allow for spatial nesting to permit examination of fish movement effects on local abundance. Control sites will be similar in character to post-construction project sites for BACI experimental designs. For post-treatment experimental designs, control sites will be similar in character to pre-construction project sites. Control sites will be an appropriate distance from the project site in relation to distances typically moved by the species studied.

Accurate, detailed, and standardized records will be kept and compare the survey results with baseline data, control sites, and performance targets to judge the performance of the compensation projects. The results will be summarized in a review of compensation effectiveness after three years. Should it be determined that the compensation habitat is not functioning properly, remedial actions will be taken that may include modification of the compensation sites.

9.2.2 Monitoring

The concept of productive capacity is central to DFO's fish habitat management activities and is defined as "the maximum natural capability of habitats to produce health fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend" (DFO 1986). Fish production is usually defined as fish biomass or population abundance for a defined area of habitat (Randall and Minns 2000). However, productive capacity must take into account the structural (e.g., biodiversity and habitat) and functional (e.g., energy and material flows) ecosystem features essential for sustained natural productivity (Minns et al. 2011).

To assess productive capacity for off-channel habitat projects, a three-tier approach is recommended. The first tier includes individual-based metrics for inferring productive capacity. These metrics include condition and growth, which are indicators of habitat quality and are sensitive indicators of environmental change (Pearson et al. 2005). Condition is used as a measure of fish nutritional status, and fish of "good condition" leading into the onset of winter months have an increased likelihood of survival (Anderson and Neumann 1996; Pope and Kruse 2007). The second tier includes population-based assessment methods for measuring productive capacity. This metric will include abundance (relative catch per unit effort, absolute abundance, density, biomass) by habitat type. The third tier includes ecosystem-based assessment methods for measuring productive capacity. This metric will include riparian vegetation cover, water

temperature, benthic invertebrates (biomass, density, richness, and diversity), and periphyton (biomass, diversity) by habitat type. Table 9.2-1 and the following sections discuss what metrics will be sampled, when sampling will occur, and target species and habitats.

Off-channel habitat in the study area is used for summer rearing and overwintering by Dolly Varden and juvenile (fry and parr) coho salmon (Rescan 2007, 2009, 2010, 2011, 2012a). To infer productive capacity of fry throughout the growing season, the average condition/growth (i.e., mean weight and fork length) attained by stream and wetland rearing fry on a common date in late-summer (before any out-migration or movement) will be quantified and compared to size after fry emergence. This will incorporate condition/growth over the entire post-emergence period. The size (biomass/weight) that fry have attained at the end of summer is important in influencing their subsequent overwinter survival (Holtby 1988; Quinn and Peterson 1996). By quantifying condition/growth of fry by a common date in late-summer, created sites and reference sites can be compared, which can take into consideration differences in fry emergence dates, water temperature and primary production between streams.

Field assessment data suggests that coho salmon parr (1+) overwinter within off-channel habitats in the study area (Rescan 2007, 2009, 2010, 2011, 2012a). Dolly Varden are resident and reside/overwinter in off-channel habitats for their entire life span (up to six years). To infer productive capacity of parr, juveniles, and adults (Dolly Varden only), the mean condition attained by stream- and wetland- rearing fish on a common date in late-summer will be quantified. This metric is directly related to over-winter survival and subsequent smolt abundance (Thedinga and Koski 1984; Quinn and Peterson 1996).

Density-dependent mortality occurs primarily in the first year (fry) of fish life (Elliot 1987; Ward and Slaney 1993; Crozier and Kennedy 1995; Whalen et al. 2000). Therefore, parr abundance is a more reliable metric of productive capacity for late-summer rearing habitat (streams and wetlands). Furthermore, late-summer standing stock is directly related to smolt production (Quinn and Peterson 1996) in coho salmon. In stream and wetland habitat, parr abundance will be estimated through closed mark-recapture methods (Johnson et al. 2007). The habitat and flow conditions created for off-channel stream habitats will likely be conducive towards the effective use of stop nets. However, three-pass removal methods (Lockwood and Schneider 2000) will be used in stream habitats, if habitat, logistics and flow conditions dictate that mark-recapture methods are not practical.

Peer-reviewed literature suggests that mark-recapture is the preferred approach (Peterson, Thurow, and Guzevich 2004; Johnson et al. 2007) because the severity of the bias is generally lower for mark-recapture estimates of stream fish than reported for multiple removal sampling. Furthermore, mark-recapture estimates are fairly robust to potential bias introduced from crew experience and variable habitat (cover percent).

The number of stream and wetland sites sampled for each off-channel site will be dictated by the length of stream habitat created, and by the number of ponds/wetlands created.

At each site, late-spring coho salmon smolt production will be estimated through the use of a smolt trap fence. Traps will be checked daily through the duration of the out-migration period. Trap efficiency and capture probability will be determined by weekly mark-recapture studies, in which a sub-sample of captured smolts will be marked and released immediately upstream of the fence and potentially recaptured in the trap. Production estimates will be derived using Darroch Analysis with Rank-Reduction (Carlson, Coggins, and Swanton 1998; Bjorkstedt 2005). Mean condition of smolts will also be assessed. It is recognized that smolt population estimates for each site may result in an underestimate of the true smolt population estimate because of a percentage of late-summer fry and parr movement out of the site. These fish may reside in other overwintering habitats (e.g., Bell-Irving River) to eventually become smolts.

Table 9.2-1. Off-channel Habitat Creation Productive Capacity Metrics

Tier	Metric	Measurement	Timing	Target Species and Life History Stage	Habitat Type	Field Method
First	Late Summer Condition	Length vs. Weight Regession Mean Condition Factor	Late May and late August	Coho Salmon - Fry	Stream and Wetland	Electrofishing and Minnow Trapping
				Dolly Varden - Fry	Stream	Electrofishing
	Late Summer Growth	Mean Fork Length Mean Weight	Late May and late August	Coho Salmon - Fry	Stream and Wetland	Electrofishing and Minnow Trapping
				Dolly Varden - Fry	Stream	Electrofishing
	Late Summer Condition	Length vs. Weight Regession Mean Condition Factor	Late August	Coho Salmon - Parr	Stream and Wetland	Electrofishing and Minnow Trapping
				Dolly Varden - Parr, Juvenile, Adult	Stream and Wetland	Electrofishing and Minnow Trapping
Second	Late Summer Abundance	Density/ Abundance	Late August	Coho Salmon - Parr	Stream (by habitat unit) and Wetland	Three-Pass-Removal/Mark Recapture
				Dolly Varden - Parr, Juvenile, Adult	Stream (by habitat unit) and Wetland	Three-Pass-Removal/Mark Recapture
	Early Spring Abundance	Density/ Abundance	April	Coho - Smolts	Stream and Wetland	Smolt Fence
				Dolly Varden - Parr, Juvenile, Adult	Stream and Wetland	Minnow Trap Mark Recapture
Third	Primary and Secondary Productivity	Biomass/ Density/ Richness/ Diversity	August	Benthic Invertebrate	Stream and Wetland	Surber Sampler
				Periphyton	Stream	Rock Scraping/Hester-Dendy Sampler
	Water Quality	Dissolved Oxygen Nitrate Phosphorus Ammonia pH Suspended Sediment	March and August	NA	Stream and Wetland	Water Quality Meter, Water Samples
	Riparian Vegetation	Percent Cover Species Composition	August	NA	Riparian	Line Transects/Quadrats
	Water Quantity	Discharge	Continuous	NA	Stream and Wetland	Data Logger
	Water Temperature	Temperature	Continuous	NA	Stream	Data Logger

NA = not applicable

Since Dolly Varden in the fish and aquatic habitat study area are not migratory, late-spring Dolly Varden (juvenile and adult) population estimates will be estimated in streams (pool habitats) and wetlands through the use of minnow trap mark-recapture methods. Mean condition of resident Dolly Varden will also be assessed.

As a measure of primary and secondary productivity, benthic macroinvertebrates and periphyton will be sampled at created and reference sites during the late-summer. Their community structure (species richness and diversity, relative abundance) and biomass is responsive to changes in water quality and physical habitat features (e.g., substrate type). Water quality will be monitored at the sites, which will include dissolved oxygen (wetlands and streams), nitrate, phosphorous, ammonia, pH, and suspended sediment (Pearson et al. 2005). Water temperature and water levels will be monitored continuously throughout the year through the use of data loggers at each site.

The function that the riparian zone provides to fish, fish habitat, and productivity (primary and secondary), will be assessed at each site. Measures of riparian cover (e.g., percent area), mean stem density and species composition will be monitored.

10. Consultation with First Nations and Stakeholders

Key Aboriginal groups and stakeholders, as identified in the Section 11 Order issued by British Columbia Environmental Assessment Office, within the fisheries study area are: DFO, MOE, Gitanyow First Nation and Wilp Wii'litsxw, Gitxsan First Nation, Skii km Lax Ha, Tahltan Nation, and Nisga'a Nation. Consultation with the DFO, BC MOE and Aboriginal group representatives was initiated early in the baseline data assessment phase and environmental assessment process through fisheries working group meetings and consultations. The goal of the meetings and consultations is to ensure knowledge and concerns of all parties were brought forward to be addressed and incorporated into the development of the baseline reports and environmental assessment, including compensation strategies. Fisheries working group meetings have been held since 2008 and will be ongoing throughout the compensation development process.

Secondly, Aboriginal groups and stakeholders were invited to review and comment upon baseline work plans and baseline reports and provide suggestions for fish habitat compensation projects within the study area watersheds. Public open houses were held to educate the public about the Project and answer questions and respond to comments.

Consultation with the general public, stakeholders and Aboriginal groups will be ongoing during the Environmental Assessment Application process. During the application review period, Seabridge will engage the public and Aboriginal groups by publishing notices in local publications and make copies of the Environmental Assessment Application available in local libraries and/or other suitable generally accessible locations. Seabridge will respond to information requests and comments received through the British Columbia Environmental Assessment Office to address specific issues or concerns raised by the participants.

11. Cost Estimate

Preliminary ranges of cost estimates for construction were developed for the sites described in the Plan (Table 11-1). The primary factors affecting the cost of building the proposed fish habitat compensation sites are:

- the location of the sites (i.e., presence of roads);
- overall extent and total area of habitat to build;
- extent of excavation;
- complexity of the proposed features;
- heavy equipment requirements; and
- personnel requirements.

A range of estimates for the duration of construction is provided (i.e., weeks, months, etc.).

Table 11-1. Costs and Planning for Compensation Sites

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Area to Build (ha)	Heavy-Lift Helicopter Required	Minimum Heavy Equipment Required	Existing Road Access	Access Cost	Construction Complexity and Duration	Onsite Construction Cost (excluding access costs)
Treaty	-	Treaty Creek	1	Off-channel pond and side channel	15.8	No	2 excavators, bulldozer	No*	Moderate	Complex, 3 to 7 months	3.8 M
Bell-Irving	Taft	Taft Creek	1	Off-channel pond and side channel	4.7	No	excavator, bulldozer, dump trucks	Yes	Low	Complex, 1 to 3 months	2.5 M

**Adjacent to proposed Treaty Creek Access Road*

References

Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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Map Pockets

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Figure 2.2-1
Tailing Management Facility Watersheds:
Channel Morphology

Reach Break
Watershed

Fish Obstacle
Beaver Dam
Cascade
Log Jam
Other

Channel Morphology
Cascade Pool
Large Channel
Riffle Pool
Step Pool
SHIM Wetland

Slope
< 20 % Slope
20 - 30 % Slope
> 30 % Slope
Paved Road
Gravel Road
Rough Road

Topography
River - Indefinite
Beaver Dam
Rapids
Intermittent or Indefinite Lake
Swamp
Marsh
Glacier
Icefield
Sand or Gravel Bar
20 m Contour
100 m Contour
Depression Contour
Indefinite Contour
Access Road

Collection Ditch
Collection Pipeline
Collection Tunnel
Culvert
Diversion Ditch
Diversion Pipeline
Diversion Tunnel
Penstock
Spillway
Valve

Landfarm / Landfill
Rock Storage Facility
Ore Stockpile
Till Stockpile
Subsidence Zone
Haul Road
Borrow Area
Log Landing
Waste Area
Dam
Pond
Glacier Diversion Inlet
Snow Storage

1:10,000

0 500 1,000
Metres

Date: January 2, 2013
File Reference: KSM-06-138
Projection: UTM9, NAD83

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Figure 2.2-2
Tailing Management Facility Watersheds: Rearing Habitat

Fish Obstacle
- Beaver Dam
- Cascade
- Log Jam
- Other

Rearing Habitat Quality Rank
- Good
- Fair
- None
- Poor
- Density Site
- SHIM - Mapped Wetland

Slope
- < 20 % Slope
- 20 - 30 % Slope
- > 30 % Slope

Topography
- River - Indefinite
- Beaver Dam
- Rapids
- Paved Road
- Gravel Road
- Rough Road
- 20 m Contour
- 100 m Contour
- Depression Contour
- Indefinite Contour
- Intermittent or Indefinite Lake
- Swamp
- Marsh
- Glacier
- Icefield
- Sand or Gravel Bar

Infrastructure
- Incinerator
- Sediment Fence
- Berm
- Diversion Ditch
- Collection Ditch
- Diversion Tunnel
- Pipeline
- Spillway
- Tunnel
- Transmission Line
- Access Road

- Infrastructure
- Dam
- Lined Pond
- Pond
- Gravel Beach Cover
- Tailing Cell
- Borrow Pit
- Landfarm / Landfill
- Ore Stockpile
- Quarry
- Soil Storage
- Haul Road

1:10,000

0 500 1,000

Metres

Date: July 28, 2009
Updated: February 11, 2010
File Reference: KSM-06-028
Projection: UTM9, NAD83

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Figure 2.2-3
Tailing Management Facility Watersheds:
Spawning Habitat

- FHAP Locations
- Reach Break
- Watershed

Fish Obstacle
- Beaver Dam
- Cascade
- Log Jam
- Other

Spawning Habitat Quality Rank
- Good
- Fair
- None
- Poor
- SHIM - Mapped Wetland

Topography
- River - Indefinite
- Beaver Dam
- Rapids

- Paved Road
- Gravel Road
- Rough Road

Slope
- < 20 % Slope
- 20 - 30 % Slope
- > 30 % Slope
- Intermittent or Indefinite Lake
- Swamp
- Marsh
- Glacier
- Icefield
- Sand or Gravel Bar

- 20 m Contour
- 100 m Contour
- Depression Contour
- Indefinite Contour
- Snow Storage
- Collection Ditch
- Collection Pipeline
- Collection Tunnel
- Culvert
- Diversion Ditch
- Diversion Pipeline
- Diversion Tunnel
- Penstock
- Spillway
- Valve

- Landfarm / Landfill
- Rock Storage Facility
- Ore Stockpile
- Till Stockpile
- Subsidence Zone
- Haul Road

1:10,000

0 500 1,000

Metres

Date: December 4, 2012
File Reference: KSM-06-139
Projection: NAD 1983 UTM Zone 9N

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Figure 2.2-4
Tailing Management Facility Watersheds:
Over-Wintering Habitat

- FHAP Locations
- Reach Break
- Watershed

Fish Obstacle
- Beaver Dam
- Cascade
- Log Jam
- Other

Overwintering Habitat Quality Rank
- Good
- Fair
- None
- Poor
- SHIM - Mapped Wetland

Slope
- < 20 % Slope
- 20 - 30 % Slope
- > 30 % Slope

Topography
- River - Indefinite
- Beaver Dam
- Rapids
- Paved Road
- Gravel Road
- Rough Road
- 20 m Contour
- 100 m Contour
- Depression Contour
- Indefinite Contour
- Intermittent or Indefinite Lake
- Swamp
- Marsh
- Glacier
- Icefield
- Sand or Gravel Bar

- Berm
- Collection Ditch
- Collection Pipeline
- Culvert
- Diversion Ditch
- Diversion Pipeline
- Diversion Tunnel
- Pipeline
- Sediment Fence
- Spillway

- Quarry
- Soil Storage
- Stockpile / Borrow Pit
- Till Stockpile
- Dam
- Lined Pond
- Pond
- Rip Rap
- Tailing Cell

1:10,000
0 500 1,000
Metres

Date: December 4, 2012
File Reference: KSM-06-140
Projection: UTM9, NAD83

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Figure 2.2-5
Tailing Management Facility Watersheds: Overall Habitat

FHAP Locations
Reach Break
Watershed

Fish Obstacle
Beaver Dam
Cascade
Log Jam
Other

Overall Habitat Quality Rank
Important
Marginal
SHIM - Mapped Wetland

Topography
River - Indefinite
Beaver Dam
Rapids
Paved Road
Gravel Road
Rough Road
20 m Contour
100 m Contour
Depression Contour
Indefinite Contour
Intermittent or Indefinite Lake
Swamp
Marsh
Glacier
Icefield
Sand or Gravel Bar

Slope
< 20 % Slope
20 - 30 % Slope
> 30 % Slope

Infrastructure
Incinerator
Sediment Fence
Berm
Diversion Ditch
Collection Ditch
Diversion Tunnel
Pipeline
Spillway
Tunnel
Transmission Line
Access Road
Infrastructure
Dam
Lined Pond
Pond
Gravel Beach Cover
Tailing Cell
Borrow Pit
Landfarm / Landfill
Ore Stockpile
Quarry
Soil Storage
Haul Road

1:11,000

0 750 1,500

Metres

Date: July 28, 2009
Updated: December 04 2012
File Reference: KSM-06-036
Projection: NAD 1983 UTM Zone 9N

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Appendix 1.1-1

DFO Guideline Letter on Fish Habitat Compensation for the KSM Project

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Our File Number
08-HPAC-PA1-00001

July 27, 2010

Vivian Au, Project Manager
Canadian Environmental Assessment Agency
Pacific and Yukon Region
757 West Hastings Street, Suite 320
Vancouver, BC V6C 1A1

By email

Dear Vivian,

Subject: KSM Mine Project Draft Application Information Requirements
Fisheries and Oceans Canada Comments

Fisheries and Oceans Canada (DFO) reviewed the draft Application Information Requirements (dAIR) prepared by Rescan Environmental Services Ltd. for Seabridge Gold Inc. (Seabridge), dated June 15, 2010. DFO notes that comments were provided on earlier versions of this document and our comments were incorporated into the June 15, 2010 version.

DFO is providing further information to aid Seabridge in its development of a "conceptual fish habitat compensation plan to offset the potential fish habitat impacts that is consistent with DFO's *Policy for the Management of Fish Habitat*" (Section 11.7.6, Lines 31 and 32). In addition, to avoid possible confusion, DFO recommends the words "conceptual fish habitat compensation plan" be replaced with "a technically feasible fish habitat compensation plan" in this section.

When developing a fish habitat compensation plan, the following factors should be considered in compensation planning and, where applicable, addressed in the compensation plan rationale and objectives:

- DFO's hierarchy of preferences, as described in Section 4.1 of DFO's *Practitioner's Guide to Habitat Compensation*;
- Fish species or stocks targeted in compensation objectives, and any fisheries management objectives, fishery use, or potential use of fish in the project area;

- Opportunities to improve existing impacts or constraints to fish and fish habitat in the watershed;
- First Nations traditional access to fish in the area, and traditional uses and ecological knowledge;
- Compliance of compensation plans with recovery planning for species listed under the *Species at Risk Act*;
- The type, amount and supply of habitat that is at both the impact and compensation sites;
- The amount and temporal nature of impact (whether impacts are permanent or temporary);
- The risk of failure and the time lag until compensatory habitats become fully functional;
- When determining potential compensation work locations, consideration should be given to the potential for the proposed project to adversely affect the compensation works in the future;
- Where existing habitat is to be enhanced, the intrinsic value of this habitat must be considered when determining the amount of productive capacity gained through compensation (i.e., enhancement); and,
- Compensation works should be designed to function in perpetuity.

It is important to note that the KSM Mine Project has two separate regulatory instruments that necessitate fish habitat compensation plans. These include: (1) authorization under subsection 35(2) of the *Fisheries Act* for the harmful alteration, disruption or destruction (HADD) of fish habitat and (2) listing under Schedule 2 of the *Metal Mining Effluent Regulations* (*MMER*). As a result, Seabridge should develop **two separate** fish habitat compensation plans to offset the impacts resulting from the following:

1. The HADD of fish habitat resulting from the project (including the dams and associated infrastructure required for the tailings impoundment area (TIA) and loss of habitat due to downstream flow impacts, transmission lines, road building, etc.); and
2. The impacts to fish habitat resulting from the deposit of a deleterious substance into the TIA.

Both plans should be prepared in accordance with DFO's national *Policy for the Management of Fish Habitat (1986).*

Two separate sections should be added into the dAIR under Section 11.7.7 Mitigation and Environmental Management. One section should be titled "*Fisheries Act* subsection 35(2) Fish Habitat Compensation Plan" and the other should be titled "*MMER* subsection 27.1 Fish Habitat Compensation Plan". Each section of the dAIR should include the appropriate components listed below:

1. ***Fisheries Act* subsection 35(2) Fish Habitat Compensation Plan**

- A detailed description of the fish habitat likely to be impacted (i.e., type of habitat, species present, productivity) and the extent (i.e., square metre/impacted habitat type) and expected duration of impact;
- A rationale summarizing how the above factors were addressed and considered in the compensation plan;
- A clear outline of the objectives of the compensation plan which include species and stocks targetted, linkage to fisheries management objectives, and type and amount of habitat compensation being proposed;
- The option chosen from the hierarchy of preferences (as outlined in DFO's *Policy for the Management of Fish Habitat*), and/or a rationale as to why a combination of the preferences was chosen. If a less preferred compensation option (i.e., lower down DFO's hierarchy of preferences) is proposed, then a rationale should be provided for moving down the hierarchy of preferences;
- A detailed description of the compensation sites and planned compensation works. This should include photographs and sketches/drawings of the sites identifying the approximate location (geographic coordinates), area, number and dimensions of compensation works and structures;
- Characterization of the habitat gains expected from the compensation works (i.e., the type and amount of habitat to be created, the species that will benefit, the habitat function or capacity that will be created, improved or enhanced, and how such gains will offset the HADD and achieve no net loss in the productive capacity of fish habitat);
- If habitat ratios (i.e., compensatory habitat : impacted habitat) were used in developing the compensation plan, a description of how the ratios are intended to offset the losses associated with the HADD should be provided;
- Identification of the factors limiting the productive capacity and habitat function of the area in which the compensation works are being proposed;
- A description of any existing habitat in the area of the proposed compensation (i.e., type, species present, productivity) should be included;
- If applicable, identification of established stakeholder groups (e.g., Nisga'a Nation, First Nations, public) and confirmation that consultation has occurred, where necessary;
- The timeline for implementing the compensation plan;
- The construction details (i.e., machine access routes, mitigation measures to prevent additional HADDs during construction, construction methods, etc.);
- Issues that could compromise the success of the compensation works (e.g., site accessibility, downstream fish obstructions, etc.);

- Confirmation of land tenure, legal right of access, and management authority for compensation works (i.e., evidence to support the ability of Seabridge to construct and maintain the compensation works);
- Environmental monitoring commitments (e.g., a description of compliance and effectiveness monitoring that will take place in relation to the compensation works, a description of post construction compensation monitoring, etc.); and
- Compensation plan costing details – note that DFO requires an irrevocable letter of credit to cover the costs of mitigation, compensation, and monitoring measures for the proposed compensation prior to issuance of an authorization for impacts to fish habitat. An estimate of these costs should be provided to DFO during the environmental assessment.

2. *MMER* subsection 27.1 Fish Habitat Compensation Plan

The compensation plan for impacts resulting from the deposit of deleterious substances into a TIA requires the following information as described in the *MMER* subsection 27.1.

- A description of the location of the tailings impoundment area and the fish habitat affected by the deposit;
- A quantitative impact assessment of the deposit on the fish habitat;
- A description of the measures to be taken to offset the loss of fish habitat caused by the deposit;
- A description of the measures to be taken during the planning and implementation of the compensation plan to mitigate any potential adverse effect on the fish habitat that could result from the plan's implementation;
- A description of measures to be taken to monitor the plan's implementation;
- A description of the measures to be taken to verify the extent to which the plan's purpose has been achieved;
- A description of the time schedule for the plan's implementation, which time schedule shall provide for achievement of the plan's purpose within a reasonable time;
- An estimate of the cost of implementing each element of the plan; and
- An irrevocable letter of credit to cover the plan's implementation costs, which letter of credit shall be payable upon demand on the declining balance of the implemenation costs (required at the time of the final compensation plan). An estimate of the cost should be provided during the environmental assessment.

In addition to the above required information, Seabridge should consider the guidance provided in the section titled "*Fisheries Act* subsection 35(2) Fish Habitat Compensation

Plan", as that section contains greater detail and guidance that may aid in the development of a fish habitat compensation plan that is acceptable to DFO.

It is important to note that fish habitat compensation is considered as mitigation to offset adverse environmental effects identified during the environmental assessment of a proposed project and can inform the determination of the significance of environmental effects.

The information requested above constitutes the information necessary for DFO to determine whether the fish habitat compensation plans will individually result in no net loss in the productive capacity of fish habitat. During its review of the above information, DFO may identify additional information necessary to inform its determination.

Please do not hesitate to contact me at (604) 666-1349 if you have any questions or concerns.

Sincerely,

Brenda Andres
Environmental Assessment Analyst,
Environmental Assessment and Major Projects
Oceans, Habitat & Enhancement Branch

cc: P. Menning, DFO
D. Wensauer, Transport Canada
T. Paul, Environment Canada
K. McPherson, Natural Resources Canada
M. Campbell, Natural Resources Canada

Appendix 3.2-1

Annotated Bibliography of Dolly Varden Habitat Preferences

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Appendix 3.2-1. Annotated Bibliography of Dolly Varden Habitat Preferences

Andrew, J.H., N. Jonsson, B. Jonsson, K. Hindar, and T.G. Northcote. 1992. Changes in use of lake habitat by experimentally segregated populations of cutthroat trout and Dolly Varden char. Ecography 15: 245-252.

The role of competition in a lacustrine community of two salmonid species, cutthroat trout Oncorhynchus clarki and Dolly Varden char Salvelinus malma, was studied in three coastal British Columbia lakes. Habitat use by the species alone (allopatric) and in coexistence with each other (sympatric) was investigated by gill netting at 0-40 m depth contours (surface to bottom) so that several habitats (littoral, epipelagic. pelagic, epibenthic) were sampled. From June to October, trout used mainly littoral and epipelagic habitats in sympatry and allopatry. Char used all habitats in allopatry and deep habitats (pelagic, epibenthic) not frequented by trout in sympatry. The two species were thus spatially segregated with depth in sympatry. Diel (day, night) and seasonal changes (spring, summer, autumn) in habitat use were not pronounced. The shift in habitat use by experimentally allopatric char but not trout suggests that the effects of competition between sympatric trout and char for habitat resources are greater on the char.

Andrusak, H., and T.G. Northcote. 1971. Segregation between adult cutthroat trout (*Salmo clarki*) and Dolly Varden (*Salvelinus malma*) in small coastal British Columbia lakes. Journal of the Fisheries Research Board of Canada 28: 1259-1268.

Comparison of spatial distributions and food of allopatric populations of *S. clarki* and *S. malma* in two lakes and of sympatric populations in a third lake suggested interactive segregation throughout the spring and summer but no diel migration was noted. Changes in food habits closely corresponded to seasonal changes in vertical distribution. A wide range of food organisms was eaten from surface, midwater, and benthic sources. Allopatric Dolly Varden underwent diel changes in spatial distribution, with many being caught in onshore waters near the surface at night. They were absent from such areas in the day, apparently occupying offshore waters at greater depths. Their diet throughout summer consisted largely of surface insects and zooplankton, with lesser amounts of bottom fauna. Sympatric cutthroat trout and Dolly Varden were spatially segregated throughout the summer. Cutthroat trout occurred and fed mostly near the surface in littoral areas. In contrast, Dolly Varden were offshore and benthic in distribution and fed primarily on bottom organisms. By comparing distribution and food habitat in allopatric and sympatric populations, it was suggested that competition for food may contribute to their segregation in sympatry. Although segregation of these species when cohabiting may involve interactive processes, the possibility of selective differences being of importance cannot be dismissed.

Baxter, C.V., K.D. Fausch, M. Murakami, and P.L. Chapman. 2004. Fish invasion restructures stream and forest food webs by interrupting reciprocal prey subsidies. Ecology 85: 2656-2663.

Habitat alteration and biotic invasions are the two leading causes of global environmental change and biodiversity loss. Recent innovative experiments have shown that habitat disturbance can have drastic effects that cascade to adjacent ecosystems by altering the flow of resource subsidies from donor systems. Likewise, exotic species invasions could alter subsidies and affect distant food webs, but very few studies have tested this experimentally. Here we report evidence from a large-scale field

experiment in northern Japan that invasion of non-native rainbow trout (*Oncorhynchus mykiss*) interrupted reciprocal flows of invertebrate prey that drove stream and adjacent riparian forest food webs. Rainbow trout usurped terrestrial prey that fell into the stream, causing native Dolly Varden charr (*Salvelinus malma*) to shift their foraging to insects that graze algae from the stream bottom. This indirectly increased algal biomass, but also decreased biomass of adult aquatic insects emerging from the stream to the forest. In turn, this led to a 65% reduction in the density of riparian-specialist spiders in the forest. Thus, species invasions can interrupt flows of resources between interconnected ecosystems and have effects that propagate across their boundaries, effects that may be difficult to anticipate without in-depth understanding of food web relationships.

Bjornn, T.C., S.C. Kirking, and W.R. Meehan. 1991. Relation of cover alteration to the summer standing crop of young salmonids in small Southeast Alaska streams. Transactions of the American Fisheries Society 120: 562-570.

Summer abundance of young coho salmon *Oncorhynchus kisutch*, steelhead *O. mykiss*, and Dolly Varden *Salvelinus malma* was assessed in small streams on Prince of Wales Island, Alaska, in an attempt to measure the response of these fish to various types of cover alterations. The standing crop of subyearlings decreased during summer, but none of the decrease could be attributed to the changes in cover we made. Subyearling coho salmon (about 75% of the fish present) did not respond either to the removal of natural riparian vegetation or to the addition of simulated riparian canopy, large boulders, woody debris, or simulated undercut banks. Localized movements within the streams were sufficient to provide relatively rapid recolonization of the experimental habitat units. The forms of cover we evaluated were relatively unimportant in regulating abundance of young coho salmon in small streams.

Bramblett, R.G., M.D. Bryant, B.E. Wright, and R.G. White. 2002. Seasonal use of small tributary and main-stem habitats by juvenile steelhead, coho salmon, and Dolly Varden in a southeastern Alaska drainage basin. Transactions of the American Fisheries Society 131: 498-506.

The movement of juvenile salmonids between small tributaries and main-stem habitats in southeast Alaska watersheds is poorly understood. We observed movements of steelhead, *Oncorhynchus mykiss*, coho salmon, *O. kisutch*, and Dolly Varden, *Salvelinus malma*, between mainstem and tributary habitats at weirs located on tributaries in the Staney Creek watershed in southeast Alaska. We used seasonal relative abundance (catch per unit effort) in eight main-stem reaches and eight tributaries to corroborate observed movement in the two streams with weirs. We observed juvenile steelhead and coho salmon moving through the weirs into tributaries during the fall as flows increased and temperatures decreased. The relative abundance of steelhead was greater in mainstem sites than in tributaries during the summer, whereas during spring and fall relative abundance in the tributaries was similar to that in the mainstem. Juvenile coho salmon were abundant in tributaries during all seasons. The relative abundance of Dolly Varden was greater in the tributaries than in the mainstem during all seasons. These results underscore the significance of links between mainstem habitats and small tributaries for production of juvenile salmonids.

Bryant, M.D. 1984. Distribution of salmonids in the Trap Bay Basin, Tenakee Inlet. Pages 17-31 In: W.R. Meehan, T.R. Merrell, and T.A. Hanley (editors). Fish and Wildlife Relationships in Old-Growth Forests: Proceedings of a Symposium. American Institute of Fisheries Research Biologists, Juneau, Alaska.

Because land management may affect a stream at various points along its progression to the sea, it is important to identify zones used in the watershed by juvenile salmonids. This 2-year study examined the distribution of juvenile salmonids in an undisturbed, old-growth forest drainage. The purpose of the study was to determine the distribution of juvenile salmonids in a small stream basin from the main

stream through the upper tributaries. Differences in density, species ratios and size among juvenile salmonids in main-stream zones, lower tributary zones, and upper tributary zones were observed. Upper reaches of tributaries were used by age-0 coho, cutthroat trout, and Dolly Varden. Lower reaches of tributaries were extensively used by juvenile coho of all age-classes and Dolly Varden up to about 120 mm in length. Main-stream zones were sparsely populated by all species, but where off-channel rearing areas were available, coho were more abundant. Differences in density occurred from early summer to early fall.

Bryant, M.D., N.D. Zymonas, and B.E. Wright. 2004. Salmonids on the fringe: Abundance, species composition, and habitat use of salmonids in high-gradient headwater streams, southeastern Alaska. Transactions of the American Fisheries Society 133: 1529-1538.

We evaluated the species distribution, abundance, and habitat relationships of salmonids in small first- to second-order headwater streams in southeast Alaska. Streams were separated into three zones based on gradient and sampled during the spring, summer, and fall. Dolly Varden *Salvelinus malma* were found in all streams where fish were present. They were the dominant species in moderate (mean gradient = 5.5%) and high-gradient (mean gradient = 12.9%) zones. Coho salmon *Oncorhynchus kisutch* fry and parr were the dominant species in the low-gradient zone (mean gradient = 3.1%) but were present in higher-gradient zones. Small numbers of steelhead *O. mykiss* parr were present in all three zones in the spring and fall. Few were captured during the summer. Coastal cutthroat trout O. clarkii were found primarily in one stream and in all three zones. The density of all species decreased as gradient increased. Anadromous Dolly Varden in spawning condition were observed in the fall up to the highest accessible locations in four streams. Salmonids use high-gradient reaches when pools are present and accessible. Headwater tributaries comprise a large proportion of most southeast Alaska watersheds, and the combined contribution from all of these tributaries to the fish community may be large. The results from this study underscore the importance of maintaining access for fish throughout watersheds and into small high-gradient streams.

Bugert, R.M., T.C. Bjornn, and W.R. Meehan. 1991. Summer habitat use young salmonids and their response to cover and predators in a small southeast Alaska stream. Transactions of the American Fisheries Society 120: 474-485.

We observed young coho salmon *Oncorhynchus kisutch*, steelhead *O. mykiss*, and Dolly Varden *Salvelinus malma* in a second-order stream on Prince of Wales Island, Alaska, to assess differences between species in habitat use and response to cover and predators. Habitat use by subyearlings of the three species differed primarily in depth of water and position in the water column. Coho salmon selected the relatively deep areas of the small stream; steelhead were more evenly spread across the bottom, regardless of depth; and Dolly Varden were close to the bottom in water less than 20 cm deep. All three species selected lower positions in the water column in pools without cover than in pools with riparian or instream cover. We detected no shift in habitat use in response to fish predators.

Dolloff, C.A. 1986. Effects of stream cleaning on juvenile coho salmon and Dolly Varden in southeast Alaska. Transactions of the American Fisheries Society 115: 743-755.

This paper describes the effects of selective removal of woody debris on populations of juvenile coho salmon *Oncorhynchus kisutch* and Dolly Varden *Salvelinus malma* in two small streams on Prince of Wales Island, Alaska, during the summers of 1979-1981. These streams contained debris left when surrounding forests were clear-cut in the late 1960s. Debris smaller than 60 mm in diameter and larger debris not embedded in the stream channel were manually removed from half of the study reach on each stream in 1979 by state-of-the-art techniques. Immigration and emigration of fish from the study sections and intrastream movements were very limited after an initial period of population adjustment

in the spring regardless of treatment. Population densities and production of both species were typically higher in sections where debris accumulations had not been removed. Production of age-0 + and age-1 + coho salmon and age-1 + and age-2 + Dolly Varden during the June-September period ranged from 0.70 to 2.22 g/m^2 in the cleaned sections and from 0.84 to 2.10 g/m^2 in the uncleaned sections. Carrying capacities for both species were lower in cleaned sections despite the use of selective techniques for removing woody debris.

Dolloff, C.A., and G.H. Reeves. 1990. Microhabitat partitioning among stream-dwelling juvenile coho salmon, *Oncorhynchus kisutch*, and Dolly Varden, *Salvelinus malma*. Canadian Journal of Fisheries and Aquatic Sciences 47: 2297-2306.

Microhabitat use and partitioning among 0+ and 1+ coho salmon, Oncorhynchus kisutch, and age 0+, 1+, and 2+ Dolly Varden, *Salvelinus malma*, was studied in small (<2 m wide), natural streams on Prince of Wales Island, Alaska, and in laboratory stream channels. Coho salmon occupied midwater positions that they defended from other fish. Dolly Varden were more closely associated with the stream bottom and were seldom territorial. For each species, the depth of water, depth of focal point, and distance of the nearest fish increased with fish size, whereas the distance to nearest cover decreased as fish size increased. Most fish selected focal point velocities between 0.0-9.0 cm/s. Woody debris was the most frequently used cover type and most fish occurred over gravel substrates ranging from 2-100 mm particle diameter. Habitat use by each species in the laboratory was similar to the pattern observed in the field. Each species occupied similar habitats both when alone and when the other species was present. Although habitat use by juveniles of coho salmon and Dolly Varden overlapped among several key parameters, each species primarily exploited resources not readily available to or selected by the other in the natural streams we studied.

Elliott, S.T. 1986. Reduction of a Dolly Varden population and macrobenthos after removal of logging debris. Transactions of the American Fisheries Society 115: 392-400.

Logging debris resident for five or more years in small streams of southeastern Alaska is frequently removed to improve salmonid habitat. This practice was evaluated for its effects on juvenile anadromous Dolly Varden *Salvelinus malma* and macrobenthos populations in a small spring-fed stream during 1973-1981. Debris, consisting of limbs, needles, and fragmented logs, was removed by hand from the entire stream in July 1976. The surface area, number, and size of pools was reduced thereafter, and the water velocity increased. Macrobenthos density and invertebrate drift decreased 60-90% immediately after debris removal but returned to pretreatment levels in 1977. The Dolly Varden population decreased from 900 to less than 100 fish by 1978 and then fluctuated sharply between late 1978 and 1981. After 1978, Dolly Varden averaged 27 mm less in length and their biomass decreased from 12.5 to 3.9 g/m^2. Decrease in fish standing crop occurred in two stages: (1) an initial loss of larger fish due to reduced habitat; (2) loss of smaller individuals during November freshets thereafter. This study indicates that removal of old logging debris does not improve habitat and can result in smaller rearing populations. Old debris should not be removed unless a block to migrating adult spawners or impairment of water quality can be demonstrated.

Fausch, K.D., S. Nakano, and K. Ishigaki. 1994. Distribution of two congeneric charrs in streams of Hokkaido Island, Japan: considering multiple factors across scales. Oecologia 100: 1-12.

Salvelinus leucomaenis (white-spotted charr) and *S. malma* (Dolly Varden) are distributed throughout Hokkaido Island, Japan, but sites where they occur in sympatry are rare. In general, *S. malma* inhabit upstream reaches and *S. leucomaenis* extend downstream to the ocean. Factors influencing their distribution were analyzed at four spatial scales ranging from the whole island to individual stream pools. At the island scale, *S. leucomaenis* were found in the warmer southwest region and at lower

altitudes elsewhere, whereas *S. malma* were found in the colder northeast and at higher altitudes. At a regional scale, the downstream limit of *S. malma* and upstream limit of *S. leucomaenis* shifted to lower altitude from south-west to north-east across the island, coincident with the decrease in temperature. Further analysis showed that transition points from *S. leucomaenis* or sympatry to *S. malma* in individual watersheds were closely related to an index of cumulative mean monthly temperatures exceeding 5°C. However, at the scale of a single watershed, the transition occurred at different altitudes, gradients, and temperatures in two tributaries, apparently because stream discharge, habitat, and disturbances from floods interacted with these abiotic factors to limit distribution. The two charr species developed interspecific dominance hierarchies in individual pools, and there was strong complementary density compensation among stream pools that could be explained by interspecific competition but not by differences in habitat. However, patterns at watershed and regional scales suggested that interspecific competition interacts with temperature in complex ways. We conclude that the importance of various abiotic and biotic factors in shaping Hokkaido charr distributions depends on the scale at which they are viewed.

Fausch, K.D., S. Nakano, and S. Kitano. 1997. Experimentally induced foraging mode shift by sympatric charrs in a Japanese mountain stream. Behavioral Ecology 8: 414-420.

Foraging mode shifts may allow animals flexibility to adapt to a variety of ecological conditions. Theory holds that ectotherms such as fishes should shift from ambush to active search modes when prey density declines, to maintain a minimum encounter rate. *Salvelinus malma* (Dolly Varden) sympatric with *S. leucomaenis* (white-spotted charr) in a northern Japan mountain stream were observed to shift from ambushing drifting invertebrates at fixed focal points to picking benthic invertebrates from the substrate along circuitous routes throughout pools, as drift declined throughout summer. Experimentally reducing drift in two pools during early summer when all charr were drift foragers caused subordinate malma to make marked shifts from drift to benthic foraging within 1 h, whereas nearly all leucomaenis remained drift foragers. Some charr of both species responded to reduced drift by emigrating from pools. Combined results of three replicate experiments revealed that malma shifted to benthic foraging when their rate of drift forays was reduced below a specific threshold, thereby upholding predictions of the theory. Adaptive foraging mode shirts may promote coexistence of these congeneric charrs in reaches of Japanese mountain streams.

Hagen, J., and E.B. Taylor. 2001. Resource partitioning as a factor limiting gene flow in hybridizing populations of Dolly Varden char (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*). Canadian Journal of Fisheries and Aquatic Sciences 58: 2037-2047.

Dolly Varden char (*Salvelinus malma*) and bull trout (*Salvelinus confluentes*) hydridize in areas of secondary contact in northwestern North America but maintain their genetic integrity in spite gene flow. We examined juvenile stream ecology and adult reproductive ecology of these species in sympatry to test for specializations to alternative niches that that may act as a basis for natural selection against hybrids. Juvenile Dolly Varden occupied deeper, faster water and foraged more during daytime in the drift, whereas bull trout used shallower, slower water and made more nightime foraging attempts towards the substrate. The species showed extensive diet overlap (Schoener's index = 0.7-0.9), and we found evidence for density compensation between species among sites. Our results suggest no obvious basis for selection against hybrids at the juvenile stream-rearing life-history stage. Bull trout, however, are adfluvial, whereas Dolly Varden are permanent stream residents. Bull trout are also much larger at maturity (50-80 cm vs 12-15 cm) and build redds in faster, deeper water using larger substrate sizes. Consequently, hybrid genotypes may be selected against in these alternative life-history niches or during reproduction owing to their intermediate size at maturity and size-dependent spawning habitat use and mate choice.

Heifetz, J., M.L. Murphy, and K.V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaska streams. North American Journal of Fisheries Management 6: 52-58.

Effects of logging on preferred winter habitats of juvenile salmonids in southeastern Alaskan streams were assessed by comparing the area of preferred winter habitat in 54 reaches of 18 streams. Three types of streams were sampled at each of six locations: a stream in a mature, undisturbed forest; a stream in a clear-cut area but logged on at least one bank; and a stream in a clear-cut area with strips of forest (buffer strips) along the stream bank. To identify preferred winter habitats, we classified stream areas in 12 of 18 streams into discrete habitat types and compared the density of salmonids within these habitat types with average density of the entire reach. Most wintering coho salmon (*Oncorhynchus kisutch*), Dolly Varden (*Salvelinus malma*), and steelhead (Salmo gairdneri) occupied deep pools with cover (i.e., upturned tree roots, accumulations of logs, and cobble substrate). Riffles, glides, and pools without cover were not used. Seventy-three percent of all pools were formed by large organic debris. Reaches in clearcut areas without buffer strips had significantly less area of pool habitat than old-growth reaches. Buffer strips protected winter habitat of juvenile salmonids by maintaining pool area and cover within pools. In some cases, blowdown from buffer strips added large organic debris to the stream and increased the cover within pools.

Hume, J.M.B., and T.G. Northcote. 1985. Initial changes in use of space and food by experimentally segregated populations of Dolly Varden (*Salvelinus malma*) and cutthroat trout (*Salmo clarki*). Canadian Journal of Fisheries and Aquatic Sciences 42: 101-109.

Dolly Varden (*Salvelinus malma*) (N = 881) and cutthroat trout (*Salmo clarki*) (N = 1571) were captured from a native lacustrine sympatric stock and transferred to two nearby lakes, formerly fishless, to establish allopatric populations with genetic backgrounds similar to the donor stock. Nearshore (5- and 10-m depth contours) vertical distributions of segregated Dolly Varden and cutthroat trout, between spring and autumn of the first 18 months after transfer, did not differ significantly from those in their sympatric lake. Dolly Varden were captured mainly near the bottom while cutthroat trout were more evenly distributed throughout the water column. Nevertheless, initially the allopatric Dolly Varden rapidly became highly planktivorous, virtually eliminating midwater populations of Chaobourus trivittatus and C. americanus (third and fourth instar larvae) within a year. These results suggest that while there may be genetic control restricting broad vertical use of space by formerly sympatric Dolly Varden shortly after being placed in allopatry, such control is flexible enough that a highly benthofagous stock in sympatry quickly becomes planktovorous in the absence of cutthroat trout.

Johnson, S.W., J.F. Thedinga, and A.S. Feldhausen. 1994. Juvenile salmonid densities and habitat use in the main-stem Situk River, Alaska, and potential effects of glacial flooding. Northwest Science 68: 284-293.

Densities and habitat use of juvenile coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*O. nerka*), steelhead (*O. mykiss*), and Dolly Varden (*Salvelinus malma*) were determined in the main-stem Situk River, Alaska. Three habitat types (channel edges, willow edges, and debris pools) were sampled at two downstream sites (lower river) and at two upstream sites (upper river) biweekly from May to September and once in November 1989. For most species, fry (age 0) most often used channel edges with little cover, whereas parr (age greater than or equal to 1) almost exclusively occupied willow edges and debris pools. Within the same habitat types, densities were significantly greater for most species and life-history stages in the upper than in the lower river; steelhead parr, with densities similar in like habitats in the upper and lower river, were a notable exception. Peak fry densities (fish/100 m^2) were 2,331 coho, 155 steelhead, and 14 sockeye, whereas peak parr densities were 281 coho, 82 steelhead, and 44 Dolly Varden. Mean length of fry and parr of all species was greater in the lower river than in the upper river. With baseline information from this study, fisheries managers

can identify strategies to restore fish and habitat that could be impacted by flooding in the Situk River. Hubbard Glacier is expected to advance and dam Russell Fiord by the year 2000, and overflow from the fiord will flood the Situk River, drastically altering fish rearing habitat.

Keith, R.M., T.C. Bjornn, W.R. Meehan, N.J. Hetrick and M.A. Brusven. 1998. Response of juvenile salmonids to riparian and instream cover modifications in small streams flowing through second growth forests of southeast Alaska. Transactions of the American Fisheries Society 127: 889-907.

We manipulated the canopy of second-growth red alder Alnus rubra and instream cover to assess the effects on abundance of juvenile salmonids in small streams of Prince of Wales Island, southeast Alaska, in 1988 and 1989. Sections of red alder canopy were removed to compare responses of salmonids to open- and closed-canopy sections. At the start of the study, all potential instream cover was removed from the study pools. Alder brush bundles were then placed in half the pools to test the response of juvenile salmonids to the addition of instream cover. Abundance of age-0 coho salmon *Oncorhynchus kisutch* decreased in both open- and closed-canopy sections during both summers, but abundance decreased at a higher rate in closed canopy sections. More age-0 Dolly Varden *Salvelinus malma* were found in open-canopy sections than in closed-canopy during both summers. Numbers of age-1 and older coho salmon and Dolly Varden were relatively constant during both summers, and there was no significant difference in abundance detected between open- and closed-canopy sections. Abundance of age-0 coho salmon decreased in pools with and without additional instream cover during both summers. Abundance of age-1 and older coho salmon and age-0 Dolly Varden did not differ significantly in pools with or without added cover during either summer. Abundance of age-1 and older Dolly Varden was higher in pools with added instream cover than in pools without cover during both summers. Age-0 coho salmon decreased in abundance throughout the summer in both years. Emigration was measured in 1989 and accounted for most of the decrease in abundance. Age-0 coho salmon emigrants were significantly smaller than age-0 coho salmon that remained in the stream.

Kishi, D., M. Murakami, S. Nakano, and Y. Tanuguchi. 2004. Effects of forestry on the thermal habitat of Dolly Varden (*Salvelinus malma*). Ecological Research 19: 283-290.

Forestry activities in riparian areas are known to affect stream communities considerably. Not only do riparian deforestation resulting from agriculture or urbanization developments affect stream communities but extensive commercial plantation and forestry practices can alter stream environments adjacent to remaining, intact or secondary forests. Because forestry often includes the construction of logging roads through the riparian zone, this can directly degrade stream environments. Twelve streams in the Shiretoko Peninsula, Hokkaido were investigated so as to determine the effects of forestry practices on stream temperature, periphyton biomass, grazer (benthic invertebrates) biomass and Dolly Varden (*Salvelinus malma Walbaum*) biomass. The greater the proportion of planted area in the catchment, the higher the stream temperature. Stream temperature directly affects periphyton biomass and Dolly Varden biomass negatively. Neither stream temperature nor periphyton biomass predicted grazer biomass, whereas a positive correlation was found between grazer biomass and Dolly Varden biomass that forage on invertebrates. The overall results indicated that Dolly Varden in the Shiretoko streams were negatively affected by forestry practices and the resultant stream temperature increases. Without effective future riparian forest management, the complex effects of both riparian disturbance and ongoing global warming could further reduce Dolly Varden populations in the region.

Kitano, S., and K. Shimazaki. 1995. Spawning habitat and nest depth of female Dolly Varden, *Salvelinus malma*, of different body size. Fisheries Science (Tokyo) 61: 776-779.

Spawning habitat and nest depth in relation to female body size were studies in a small population of Dolly Varden *Salvelinus malma*. Females selected areas where gravel was prevalent and currents were slow for spawning. Neither substrate score, water depth, nor current velocity was significantly correlated with the female body size. Nest depth, however, was strongly correlated with female size. These results suggest that nest made by smaller females are more vulnerable to destruction both from flooding and from nest site reuse by later-spawning females.

Lough, M.J., S.E. Hay, D. Lowe, and D.W. Rimmer. 2003. Life History Characteristics of Dolly Varden in the Campbell River and Puntledge River Watersheds. Prepared for the British Columbia Ministry of Water, Land and Air Protection, Fish and Wildlife Sciences Allocation Section, by MJL Environmental Consultants. February 2003.

General life history information.

Milner, A.M., and R.G. Bailey. 1989. Salmonid colonization of new streams in Glacier Bay National Park, Alaska. Aquaculture and Fisheries Management 20: 179-192.

Following the rapid recession of a neoglacial ice sheet within the last 250 years, colonization of recently deglaciated streams by salmonid fishes was investigated in Glacier Bay National Park, south-eastern Alaska. The primary factors governing the establishment, species diversity composition and abundance of salmonids in Glacier Bay streams were water temperature, sediment loading and stream discharge. No salmonids were found in the turbid meltwater streams emerging from retreating ice. Coho, *Oncorhynchus kisutch* (Walbaum), and sockeye, *Oncorhynchus nerka* (Walbaum), salmon and Dolly Varden, *Salvelinus malma* (Walbaum), charr were the first salmonids to colonize the youngest clearwater stream.

Murphy, M.L., J. Heifetz, S.W. Johnson, K.V. Koski, and J.F. Thedinga. 1986. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaskan streams. Canadian Journal of Fisheries and Aquatic Sciences 43: 1521-1533.

To assess short-term effects of logging on juvenile *Oncorhynchus kisutch, Salvelinus malma, Salmo gairdneri,* and *Salmo clarki* in southeastern Alaska, we compared fish density and habitat in summer and winter in 18 streams in old-growth forest and in clearcuts with and without buffer strips. Buffered reaches did not consistently differ from old-growth reaches; clear-cut reaches had more periphyton, lower channel stability, and less canopy, pool volume, large woody debris, and undercut banks than old-growth reaches. In summer, if areas had underlying limestone, clear-cut reaches and buffered reaches with open canopy had more periphyton, benthos and coho salmon fry (age-0) than old-growth reaches. In winter, abundance of parr (age>0) depended on amount of debris. If debris was left in clear-cut reaches, or added in buffered reaches, coho salmon parr were abundance (10-22/100 m^2). If debris had been removed from clear-cut reaches, parr were scarce (<2/100 m^2). Thus, clear-cutting may increase fry abundance in summer in some streams by increasing primary production, but may reduce abundance of parr in winter if debris is removed. Use of buffer strips maintains or increases debris, protects habitat, allows increased primary production, and can increase abundance of fry and parr.

Murphy, M.L., J.F. Thedinga, K.V. Koski, and G.E. Grette. 1984. A stream ecosystem in an old-growth forest in southeastern Alaska. Part V: seasonal changes in habitat utilization by juvenile salmonids. Pages 89-98 In: W.R. Meehan, T.R. Merrell, Jr., and T.A. Hanley (editors). Fish and Wildlife Relationships in Old-Growth Forests: Proceedings of a Symposium. American Institute of Fisheries Research Biologists, Juneau, Alaska.

Seasonal changes in distribution and habitat selection by juvenile salmonid fishes were studies in Porcupine Creek, a small coastal stream in an old-growth forest in southeastern Alaska. During summer, coho salmon (*Oncorhynchus kisutch*) were distributed in both stream/estuary ecotones and freshwater reaches, and biomass (g per m^2) was directly related to total pool volume. Trout (*Salmo gairdneri*) AND Dolly Varden char (*Salvelinus malma*) were not common in the stream/estuary ecotones but were common in freshwater. Total salmonid biomass during summer was directly related to the amount of large organic debris in the stream. Tagged salmonids showed little movement during summer but redistributed themselves within the Porcupine Creek system before winter. Coho moved out of the stream/estuary ecotones to upstream freshwater areas to overwinter. In late autumn, coho used primarily large mainstream pools, backwater pools and secondary-channel pools, and trout and char used primarily debris or undercut banks on the edge of riffles. Resource managers need to take into account seasonal changes in habitat requirements when assessing the effects of logging or other land uses on fish habitat in streams.

Nakano, S., and T. Furukawa-Tanaka. 1994. Intra- and interspecific dominance hierarchies and variation in foraging tactics of two species of stream-dwelling chars. Ecological Research 9: 9-20.

Aggressive interactions, foraging behavior, habitat use and diet were studied in sympatric populations of white-sported char, *Salvelinus leucomaenis*, and Dolly Varden, *Salvelinus malma*, in a Japanese mountain stream. Underwater observations on individuals of both species revealed two distinct behavioral regimes: aggressive drift foragers and non-aggressive benthos foragers. Aggressive drift foragers defended partial territories around focal points from which they made forays to capture invertebrates drifting in the water column. Non-aggressive benthos foragers cruised around and beneath cobble in large foraging ranges that overlapped each other. Intraand interspecific, size-dependent dominance hierarchies were recognized among aggressive drift foragers, whereas non-aggressive benthos foragers showed no such relationships. Terrestrial invertebrates were the most abundant prey in the diets of drift foragers, whereas a very small proportion of the diet of benthos foragers was made up of these taxa. Benthos foragers showed more complex diet composition than drift foragers. These results suggest that non-aggressive benthos foragers may avoid not only interference but also exploitative competition by using alternative foraging tactics. The proportion of drift foragers to benthos foragers among whitespotted char was more than 35 times that among Dolly Varden. The significant difference in the proportion of each species using the two types of foraging strategy results in interspecific food segregation in sympatric populations.

Nakano, S., F. Kitano, and K. Maekawa. 1996. Potential fragmentation and loss of thermal habitats for charrs in the Japanese archipelago due to climatic warming. Freshwater Biology 36: 711-722.

The upper thermal limits of the present distributions of two charr species, Dolly Varden, *Salvelinus malm*a, and white-spotted charr, *S. leucomaenis*, in streams of the Japanese archipelago were examined using groundwater temperature as an index of thermal condition. The lower limits of the altitudinal distributions of Dolly Varden and white-spotted charr were delineated, respectively, by 8 and 16°C groundwater isotherms. The potential impact of future climatic warming on the geographical distribution, habitat extent and population fragmentation of each species was predicted at both the full archipelago and individual catchment levels. For Dolly Varden, analysis at the full archipelago level indicated a loss of 27.6, 67.2, 79.6 and 89.6% of the current geographical range,

respectively, for a 1, 2, 3 and 4°C increase in mean annual air temperature. The present distribution area of white-spotted charr would likewise reduce by 4.1, 20.5, 33.8 and 45.6%, respectively. Based on the analyses of three individual catchments, one for Dolly Varden and two for whitespotted charr, the lower habitat boundaries for the two charr species could be expected to rise increasingly to higher elevations in each catchment as warming proceeded. As a consequence, there would be large reductions in mean habitat area, with increasing habitat fragmentation followed by localized extinctions of the two species.

Northcote, T.G. 1995. Confessions of a four decade affair with Dolly Varden: a synthesis and critique of experimental tests for interactive segregation between Dolly Varden char (*Salvelinus malma*) and cutthroat trout (*Oncorhynchus clarkii*). Nordic Journal of Freshwater Research 71: 49-67.

Validation of the competitive exclusion principle has been attempted over a forty year period for species pairs of British Columbia freshwater fishes, mainly Dolly Varden and cutthroat trout, by field comparisons in sympatry and allopatry on their use of space and food resources, by laboratory study of their trophic and visual structures, by large-scale field manipulation experiments, and by controlled laboratory behavioural experiments. Although much information has been obtained on ecological interactions between the species pairs, little insight has been gained into the validity of the principle itself or the mechanisms which might support it. Probably this is the result of difficulties and lack of precision in concept definition as well as in design of appropriate experiments to test its assumptions. Precise definition of the principle may not be practical and it may be more useful to consider competitive exclusion between closely related species pairs as a quasi-permanent final state of genetically determined difference realized by a series of less fixed steps brought about by interactive segregation.

Palmisano, J.J., and W.T. Helm. 1971. Freshwater food habits of "*Salvelinus malma*" (Walbaum) on Amchitka Island, Alaska. BioScience 21: 637-641.

Stomachs from 3,672 Dolly Varden collected from September 1967 to November 1968 were examined. Aquatic invertebrates (insects and crustaceans) comprised over 90% of the diet. Food habits differed in lakes and streams. As fish size increased, diet changed and feeding activity decreased. Char selected large food items. Feeding activity was highest during summer and autumn. Feeding was more intense during daylight.

Plante, C., and J.A. Downing. 1993. Relationship of salmonine production to lake trophic status and temperature. Canadian Journal of Fisheries and Aquatic Sciences 50: 1324-1328.

Data on trout, char, and salmon from lakes in several geographic areas indicate that salmonine production (P, kilograms per hectare per year) increases with total phosphorus concentration (TP, micrograms per litre) as log10(P) = 0.47 + 0.95log10(TP) (r2 = 0.61). A positive relationship was also found between P and phytoplankton productivity and this relationship suggests that energy transfer efficiencies from phytoplankton to salmonines are reduced in eutrophic lakes. Lake area and mean depth had no significant statistical effect on P but salmonine production was significantly lower in warmer climates. Analysis of these data suggests that projected global increases in air temperatures could lead to about 50% reductions in salmonine production and yield in the north temperate zone.

Sandstrom, S.J., C.B. Chetkiewicz, and L.A. Harwood. 2001. Overwintering habitat of juvenile Dolly Varden (*Salvelinus malma* W.) in the Rat River, Nunavut, as determined by radio telemetry. Canadian Science Advisory Secretariat Research Document No. 2001/092.

In late-September 1995, a survey of the Rat River Dolly Varden (*Salvelinus malma*) stock was conducted by seining the various pools and riffle areas at the spawning and overwintering site on Fish Creek, a headwater tributary. Although this study determined the main overwintering location of the adult component of the population, it failed to find appreciable numbers of anadromous juvenile char (i.e., <400 mm) at this site. In an attempt to determine where the juvenile component of the stock resides during the late-fall, and perhaps document whether additional overwintering habitat exists for this stock, sixteen anadromous juvenile char were radio tagged on August 26 and 27, 1996, near the mouth of the river, approximately 150 km downstream of the spawning/overwintering site. Four radio-tracking flights were made along the Rat River and the Fish Creek tributary on August 30, October 6, November 9, 1996 and March 20, 1997. Results of these tracking flights found that juvenile char use the same areas for overwintering as do the adult char, i.e., several deep pools just upstream of the aufeis field. However, unlike adults juvenile char do not move into these areas until well after freeze-up. Upon completing their upstream migration to the Fish Creek tributary by mid- to late-September juvenile char first occupy areas in Fish Creek within and below the main aufeis field. Final upstream movement into the overwintering pools above the main aufeis field likely does not occur until sometime in late November. It is speculated that this behaviour may be to avoid antagonistic interactions with the spawning adult char upstream. This region of the river may also provide better cover from predators and/or may provide an area of lower energy requirement prior to freeze-up.

Swales, S., F. Caron, J.R. Irvine, and C.D. Levings. 1988. Overwintering habitats of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Keogh River system, British Columbia. Canadian Journal of Zoology 66: 254-261.

Catches of overwintering juvenile coho salmon (*Oncorhynchus kisutch*) in the Keogh River system, Vancouver Island, were higher in two small (8 and 25 ha), shallow (mean depth 2-3 m) lakes and their outlet and inlet streams than in the main river, where steelhead trout (*Salmo gairdneri*) were predominant. Dolly Varden char (*Salvelinus malma*), cutthroat trout (*Salmo clarki*), and threespine stickleback (*Gasterosteus aculeatus*) were also present in the lakes. The distribution of coho salmon in the lakes was restricted largely to areas close to the bank, with few fish being captured in offshore areas or in mid-water. The population density and biomass of coho salmon overwintering in Long Lake were estimated to be 176 fish/ha and 1.14 kg/ha, respectively. The mean length of coho salmon in the lakes was greater than that of coho salmon in the tributary streams and main river, and the mean length of the salmon in the lakes generally increased with distance away from shore.

Swales, S., R.B. Lauzier, and C.D. Levings. 1986. Winter habitat preferences of juvenile salmonids in two interior rivers in British Columbia. Canadian Journal of Zoology 64: 1506-1514.

The winter distribution and abundance of juvenile salmonids was investigated in various main channel and off-channel habitats in the Coldwater and Nicola rivers in the southern interior of British Columbia. Catches were generally low in all main channel habitats, with coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*) being most abundant and Chinook salmon and Dolly Varden char being present in smaller numbers. Coho salmon and steelhead trout catches were generally highest in pools with abundant instream and riparian cover. Steelhead trout was the main species in riprap bank protected areas, although catches were generally low. Highest overall catches were recorded in side channels and off-channel ponds, where water temperatures were usually several degrees higher than in the main river. The authors conclude that juvenile salmonids in the rivers investigated showed considerable habitat segregation during the winter. As in coastal rivers, juvenile coho salmon made extensive use of off-channel ponds, while rainbow trout and chinook salmon were generally most abundant in riprap and deep pools containing log debris, respectively.

Swales, S., and C.D. Levings. 1989. Role of off-channel ponds in the life cycle of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Coldwater River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 46: 232-242.

Off-channel ponds in the upper reaches of the Coldwater River, British Columbia, were major rearing areas for juvenile coho salmon (*Oncorhynchus kisutch*). Chinook salmon (*Oncorhynchus tshawytscha),* steelhead trout (*Salmo gairdneri*), and Dolly Varden char (*Salvelinus malma*) were generally scarce in the ponds, although they were numerous in the main river. Coho salmon were predominant at "natural" river sites while steelhead trout was the main species at sites with "rip-rap" bank stabilization. Catches of juvenile coho were much lower in the main river than in the ponds where they were the main species, and were more variable in the river. Population density and biomass estimates of juvenile coho in the ponds ranged from 0.100 fish/m^2 and 1.00 g/m^2 to 1.00 fish/m^2 and 5.15 g/m^2, compared with density estimates of 0.08-0.23 fish/m^2 in the river.

Takami, T., F. Kitano, and S. Nakano. 1997. High water temperature influences on foraging responses and thermal deaths of Dolly Varden, *Salvelinus malma*, and white-spotted charr, *S. leucomaenis*, in a laboratory. Fisheries Science (Tokyo) 63: 6-8.

Water temperature effects on foraging responses and thermal tolerances of two congeneric charrs, Dolly Varden *Salvelinus malma* and white-spotted charr *S. leucomaenis*, were examined in aquarium settings. Appetites decreased at ≥16°C for Dolly Varden at ≥24°C for white-spotted charr. The lethal temperatures were ≥20°C for Dolly Varden and ≥26°C for white-spotted charr. The upper limits of preferred temperature ranges and the lethal temperatures for Dolly Varden were significantly lower than those of white-spotted charr. Temperature preferences and thermal tolerance probably play a major role in the distribution of these two species.

Underwood, T.J., M.J. Millard, and L.A. Thorpe. 1996. Relative abundance, length frequency, age, and maturity of Dolly Varden in nearshore waters of the Arctic National Wildlife Refuge, Alaska. Transactions of the American Fisheries Society 125: 719–728.

Uncertainty about the environmental effects of oil development prompted a study of Dolly Varden *Salvelinus malma* in the nearshore waters of the Arctic National Wildlife Refuge, Alaska. Abundance of fish less than 400 mm fork length (FL), as indexed by fyke net catch per unit effort (CPUE), was significantly different among years, with the highest daily catch rates occurring in 1991, a year of heavy pack ice and relatively cold water temperatures. The CPUE for fish 400 mm or greater did not differ significantly among years. Within each sampling year, both large and small fish appeared to be more abundant in nearshore waters earlier in the summer. Lengths ranged from 53 to 734 mm. Growth was greater early in the season and in the years 1989 and 1990, and site-specific temporal changes in distribution were reflected in analysis of length data. Individual fish were aged at 1–13 years. A gonadosomatic index indicated that sexually mature fish were greater than 400 mm FL. Wide summer dispersal makes Dolly Varden less vulnerable to local coastal perturbations during the summer; however, vulnerability may be greater for stocks that must migrate seasonally through particular areas (e.g., a river mouth during fall migrations). The significant differences in local abundance patterns makes effective monitoring of the overall population size difficult. Monitoring spawners or overwintering fish in freshwater may be a more accurate means of assessing overall abundance trends.

Appendix 4.2-1

Photographs of Impacted Watercourses (MMER)

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Appendix 4.2-1. Photographs of Impacted Watercourses (MMER)

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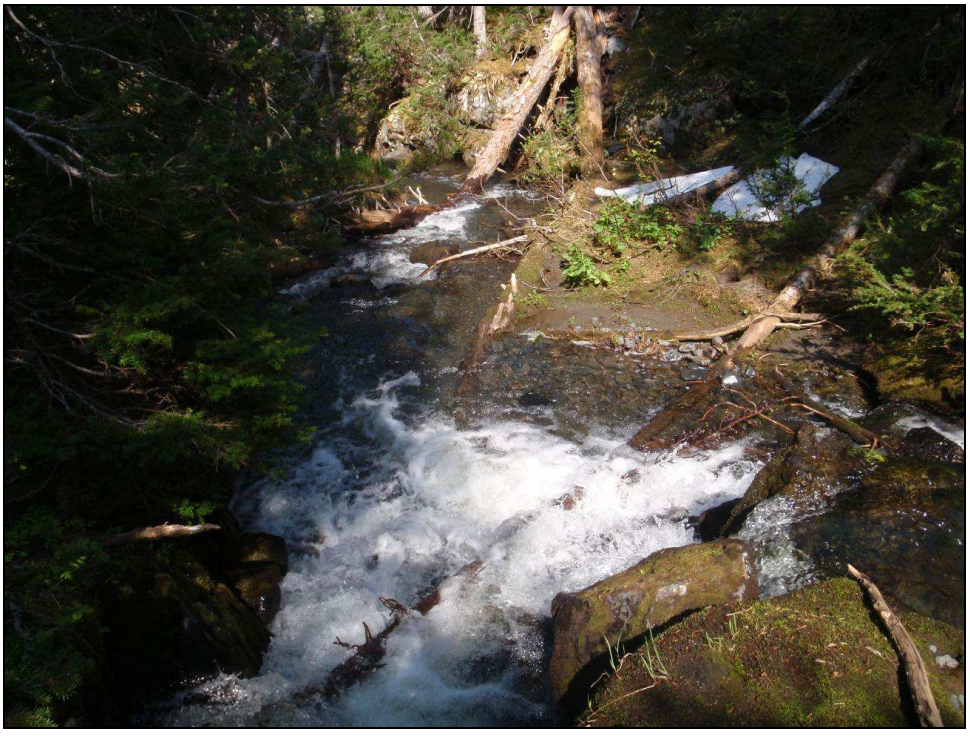

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Appendix 4.3-1

HSI Ratings and Values for Impacted Watercourses (MMER)

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Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1005

Watershed **South Teigen**

ILP **ILP 1005**

		Area 1				
Habitat Variable	**Description of Habitat**	**Value**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	ADULT					
Stream gradient (%)		14	*Low*	*0.25*	174.825	44
Cover (%)		10	Moderate	0.5		
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		43	Poor	*0.1*	174.825	17
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		14	*Low*	*0.25*	174.825	44
Substrate (% gravel and rubble(A/B/C))		0.13/0.43/0.43	Moderate	0.5		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		14	*Low*	*0.25*	174.825	44
Substrate (% gravel and rubble(A/B/C))		0.13/0.43/0.43	Moderate	0.5		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1006

Watershed **South Teigen**

ILP **ILP 1006**

		Area 1				
Habitat Variable	**Description of Habitat**	**Value**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	ADULT					
Stream gradient (%)		>20	***Low***	***0.1***	188.0122222	19
Cover (%)		5	Low	0.25		
Percent pools (%)		7.5	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		15.9	***Moderate***	***0.5***	188.0122222	94
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		>20	***Low***	***0.1***	188.0122222	19
Substrate (% gravel and rubble(A/B/C))		0.3/0.5/0.2	Moderate	0.5		
Cover (%)		5	Low	0.25		
Percent pools (%)		7.5	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		>20	***Low***	***0.1***	188.0122222	19
Substrate (% gravel and rubble(A/B/C))		0.3/0.5/0.2	Moderate	0.5		
Cover (%)		5	Low	0.25		
Percent pools (%)		7.5	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1007

Watershed South Teigen

ILP ILP 1007

Habitat Variable	Description of Habitat	Area 1					Area 2				
		Value	Rating	HSI Value	Area (m^2)	HU	Value	Rating	HSI Value	Area (m^2)	HU
	ADULT										
Stream gradient (%)		9	Moderate	0.5			20	***Poor***	***0.1***		
Cover (%)		5.9	Low	0.25			5.9	Low	0.25		
Percent pools (%)		0	***None***	***0.1***	61.11	6	0	***None***	***0.1***	321.3933333	32
Vegetation index of riparian zone		116	Moderate	0.5			116	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	EMBRYO										
Substrate (% fines)		5.5	***High***	***1***	61.11	61	5.5	***High***	***1***	321.3933333	321
Average flow (% of MAF)	ISD	NA					NA				
Average velocity (cm/s)	ISD	NA					NA				
Average temperature (°C)	Summer Temperature	8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	FRY										
Stream gradient (%)		9	Moderate	0.5			20	***Poor***	***0.1***		
Substrate (% gravel and rubble(A/B/C))		0/0.95/0.05	Low	0.2			0/0.95/0.05	Low	0.2		
Cover (%)		5.9	Low	0.25			5.9	Low	0.25		
Percent pools (%)		0	***None***	***0.1***	61.11	6	0	***None***	***0.1***	321.3933333	32
Vegetation index of riparian zone		116	Moderate	0.5			116	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	PARR										
Stream gradient (%)		9	Moderate	0.5			20	***Poor***	***0.1***		
Substrate (% gravel and rubble(A/B/C))		0/0.95/0.05	Low	0.2			0/0.95/0.05	Low	0.2		
Cover (%)		5.9	Low	0.25			5.9	Low	0.25		
Percent pools (%)		0	***None***	***0.1***	61.11	6	0	***None***	***0.1***	321.3933333	32
Vegetation index of riparian zone		116	Moderate	0.5			116	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1008

Watershed **South Teigen**

ILP **ILP 1008**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		18	***Poor***	***0.1***	231.44	23
Cover (%)		5.9	Low	0.25		
Percent pools (%)		5	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		9.4	***High***	***1***	231.44	231
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		18	***Poor***	***0.1***	231.44	23
Substrate (% gravel and rubble(A/B/C))		0.07/0.8/0.09	Moderate	0.5		
Cover (%)		5.9	Low	0.25		
Percent pools (%)		5	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		18	***Poor***	***0.1***	231.44	23
Substrate (% gravel and rubble(A/B/C))		0.07/0.8/0.09	Moderate	0.5		
Cover (%)		5.9	Low	0.25		
Percent pools (%)		5	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1009

Watershed South Teigen

ILP ILP 1009

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		1	High	1		
Cover (%)		20	High	1		
Percent pools (%)		0	***None***	***0.1***	19.5	2
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		20	***Moderate***	***0.5***	19.5	10
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.8/0.2	Low	0.2		
Cover (%)		20	High	1		
Percent pools (%)		0	***None***	***0.1***	19.5	2
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.8/0.2	Low	0.2		
Cover (%)		20	High	1		
Percent pools (%)		0	***None***	***0.1***	19.5	2
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1010

Watershed South Teigen

ILP ILP 1010

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		10	***Moderate***	***0.5***	2300.2	1150
Cover (%)		13.2	***Moderate***	***0.5***		
Percent pools (%)		36.7	High	1		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		1.3	***High***	***1***	2300.2	2300
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		10	***Moderate***	***0.5***	2300.2	1150
Substrate (% gravel and rubble(A/B/C))		0.6/0.4/0.01	High	1		
Cover (%)		13.2	***Moderate***	***0.5***		
Percent pools (%)		36.7	High	1		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		10	***Moderate***	***0.5***	2300.2	1150
Substrate (% gravel and rubble(A/B/C))		0.6/0.4/0.01	High	1		
Cover (%)		13.2	***Moderate***	***0.5***		
Percent pools (%)		36.7	High	1		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1011

Watershed South Teigen

ILP ILP 1011

Habitat Variable	Description of Habitat	Area 1 Value	Area 1 Rating	Area 1 HSI Value	Area 1 Area (m^2)	Area 1 HU	Area 2 Value	Area 2 Rating	Area 2 HSI Value	Area 2 Area (m^2)	Area 2 HU
	ADULT										
Stream gradient (%)		10	***Moderate***	***0.5***	259.88	130	20	***Poor***	***0.1***	90.475	9
Cover (%)		15	***Moderate***	***0.5***			15	Moderate	0.5		
Percent pools (%)		20	***Moderate***	***0.5***			20	Moderate	0.5		
Vegetation index of riparian zone		100	***Moderate***	***0.5***			100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	EMBRYO										
Substrate (% fines)		0	***High***	***1***	259.88	260	0	***High***	***1***	90.475	90
Average flow (% of MAF)	ISD	NA					NA				
Average velocity (cm/s)	ISD	NA					NA				
Average temperature (°C)	Summer Temperature	8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	FRY										
Stream gradient (%)		10	***Moderate***	***0.5***	259.88	130	20	***Poor***	***0.1***	90.475	9
Substrate (% gravel and rubble(A/B/C))		0.04/0.96/0	***Moderate***	***0.5***			0.04/0.96/0	Moderate	0.5		
Cover (%)		15	***Moderate***	***0.5***			15	Moderate	0.5		
Percent pools (%)		20	***Moderate***	***0.5***			20	Moderate	0.5		
Vegetation index of riparian zone		100	***Moderate***	***0.5***			100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	PARR										
Stream gradient (%)		10	***Moderate***	***0.5***	259.88	130	20	***Poor***	***0.1***	90.475	9
Substrate (% gravel and rubble(A/B/C))		0.04/0.96/0	***Moderate***	***0.5***			0.04/0.96/0	Moderate	0.5		
Cover (%)		15	***Moderate***	***0.5***			15	Moderate	0.5		
Percent pools (%)		20	***Moderate***	***0.5***			20	Moderate	0.5		
Vegetation index of riparian zone		100	***Moderate***	***0.5***			100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1012

Watershed South Teigen

ILP ILP 1012

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		10	***Moderate***	***0.5***	572.4	286
Cover (%)		26	High	1		
Percent pools (%)		27	***Moderate***	***0.5***		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		4	***High***	***1***	572.4	572
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		10	***Moderate***	***0.5***	572.4	286
Substrate (% gravel and rubble(A/B/C))		0.39/0.37/0.04	***Moderate***	***0.5***		
Cover (%)		26	High	1		
Percent pools (%)		27	***Moderate***	***0.5***		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		10	***Moderate***	***0.5***	572.4	286
Substrate (% gravel and rubble(A/B/C))		0.39/0.37/0.04	***Moderate***	***0.5***		
Cover (%)		26	High	1		
Percent pools (%)		27	***Moderate***	***0.5***		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1019

Watershed South Teigen

ILP ILP 1019

Habitat Variable	Description of Habitat	Area 1					Area 2				
		Value	Rating	HSI Value	Area (m^2)	HU	Value	Rating	HSI Value	Area (m^2)	HU
	ADULT										
Stream gradient (%)		15	***Poor***	***0.1***	1237.5	124	>20	***Poor***	***0.1***	275	28
Cover (%)		11	Moderate	0.5			11	Moderate	0.5		
Percent pools (%)		10	Moderate	0.5			10	Moderate	0.5		
Vegetation index of riparian zone		109	Moderate	0.5			109	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	EMBRYO										
Substrate (% fines)		12.8	***High***	***1***	1237.5	1238	12.8	***High***	***1***	275	275
Average flow (% of MAF)	ISD	NA					NA				
Average velocity (cm/s)	ISD	NA					NA				
Average temperature (°C)	Summer Temperature	8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	FRY										
Stream gradient (%)		15	***Poor***	***0.1***	1237.5	124	>20	***Poor***	***0.1***	275	28
Substrate (% gravel and rubble(A/B/C))		0/0.87/0.13	Low	0.25			0/0.87/0.13	Low	0.25		
Cover (%)		11	Moderate	0.5			11	Moderate	0.5		
Percent pools (%)		10	Moderate	0.5			10	Moderate	0.5		
Vegetation index of riparian zone		109	Moderate	0.5			109	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	PARR										
Stream gradient (%)		15	***Poor***	***0.1***	1237.5	124	>20	***Poor***	***0.1***	275	28
Substrate (% gravel and rubble(A/B/C))		0/0.87/0.13	Low	0.25			0/0.87/0.13	Low	0.25		
Cover (%)		11	Moderate	0.5			11	Moderate	0.5		
Percent pools (%)		10	Moderate	0.5			10	Moderate	0.5		
Vegetation index of riparian zone		109	Moderate	0.5			109	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1021

Watershed South Teigen

ILP ILP 1021

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		15	***Poor***	***0.1***	209.58	21
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		106	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		0	***High***	***1***	209.58	210
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		15	***Poor***	***0.1***	209.58	21
Substrate (% gravel and rubble(A/B/C))		0/1.0/0	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		106	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		15	***Poor***	***0.1***	209.58	21
Substrate (% gravel and rubble(A/B/C))		0/1.0/0	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		106	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1022

Watershed **South Teigen**

ILP **ILP 1022**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		18	***Poor***	***0.1***	439.28	44
Cover (%)		21.5	High	1		
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		2	***High***	***1***	439.28	439
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		18	***Poor***	***0.1***	439.28	44
Substrate (% gravel and rubble(A/B/C))		0.65/0.32/0.02	High	1		
Cover (%)		21.5	High	1		
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		18	***Poor***	***0.1***	439.28	44
Substrate (% gravel and rubble(A/B/C))		0.65/0.32/0.02	High	1		
Cover (%)		21.5	High	1		
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1023

Watershed **South Teigen**

ILP **ILP 1023**

		Area 1					Area 2				
Habitat Variable	**Description of Habitat**	**Value**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**	**Value**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	ADULT										
Stream gradient (%)		>20	***Poor***	***0.1***	253.092	25.3092	10	***Low***	***0.25***	64.19	16
Cover (%)		16.6	Moderate	0.5			16.6	Moderate	0.5		
Percent pools (%)		7.5	Moderate	0.5			7.5	Moderate	0.5		
Vegetation index of riparian zone		110	Moderate	0.5			110	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	EMBRYO										
Substrate (% fines)		5.7	***High***	***1***	253.092	253.092	5.7	***High***	***1***	64.19	64
Average flow (% of MAF)	ISD	NA					NA				
Average velocity (cm/s)	ISD	NA					NA				
Average temperature (°C)	Summer Temperature	8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	FRY										
Stream gradient (%)		>20	***Poor***	***0.1***	253.092	25.3092	10	***Low***	***0.25***	64.19	16
Substrate (% gravel and rubble(A/B/C))		0.35/0.58/0.06	Moderate	0.5			0.35/0.58/0.06	Moderate	0.5		
Cover (%)		16.6	Moderate	0.5			16.6	Moderate	0.5		
Percent pools (%)		7.5	Moderate	0.5			7.5	Moderate	0.5		
Vegetation index of riparian zone		110	Moderate	0.5			110	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		
	PARR										
Stream gradient (%)		>20	***Poor***	***0.1***	253.092	25.3092	10	***Low***	***0.25***	64.19	16
Substrate (% gravel and rubble(A/B/C))		0.35/0.58/0.06	Moderate	0.5			0.35/0.58/0.06	Moderate	0.5		
Cover (%)		16.6	Moderate	0.5			16.6	Moderate	0.5		
Percent pools (%)		7.5	Moderate	0.5			7.5	Moderate	0.5		
Vegetation index of riparian zone		110	Moderate	0.5			110	Moderate	0.5		
Average flow (% of MAF)	ISD	NA					NA				
Average temperature (°C)		8	High	1			8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA					NA				
Average pH		7.5	High	1			7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1025

Watershed **South Teigen**

ILP **ILP 1025**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		15	***Poor***	***0.1***	578.336	58
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		104	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		1.4	***High***	***1***	578.336	578
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		15	***Poor***	***0.1***	578.336	58
Substrate (% gravel and rubble(A/B/C))		0/0.99/0.01	Low	0.25		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		104	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		15	***Poor***	***0.1***	578.336	58
Substrate (% gravel and rubble(A/B/C))		0/0.99/0.01	Low	0.25		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		104	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1026

Watershed South Teigen

ILP ILP 1026

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		15	***Poor***	***0.1***	175	18
Cover (%)		14.1	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		141	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		0	***High***	***1***	175	175
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		15	***Poor***	***0.1***	175	18
Substrate (% gravel and rubble(A/B/C))		0.3/0.69/0	Moderate	0.5		
Cover (%)		14.1	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		141	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		15	***Poor***	***0.1***	175	18
Substrate (% gravel and rubble(A/B/C))		0.3/0.69/0	Moderate	0.5		
Cover (%)		14.1	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		141	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1028

Watershed **South Teigen**

ILP **ILP 1028**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		1	High	1		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***	325.5	33
Vegetation index of riparian zone		138	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		50	***Poor***	***0.1***	325.5	33
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.5/0.5	***Poor***	***0.1***		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***	325.5	33
Vegetation index of riparian zone		138	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.5/0.5	***Poor***	***0.1***		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***None***	***0.1***	325.5	33
Vegetation index of riparian zone		138	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1029

Watershed South Teigen

ILP ILP 1029

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		1	High	1		
Cover (%)		0	***None***	***0.1***	594	59
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		60	***Poor***	***0.1***	594	59
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.4/0.6	***Poor***	***0.1***		
Cover (%)		0	***None***	***0.1***	594	59
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.4/0.6	***Poor***	***0.1***		
Cover (%)		0	***None***	***0.1***	594	59
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1030

Watershed South Teigen

ILP ILP 1030

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		1.3	***Poor***	***0.1***	2985.8	299
Percent pools (%)		1.7	Moderate	0.5		
Vegetation index of riparian zone		134	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		12.9	***High***	***1***	2985.8	2986
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.14/0.73/0.13	Moderate	0.5		
Cover (%)		1.3	***Poor***	***0.1***	2985.8	299
Percent pools (%)		1.7	Moderate	0.5		
Vegetation index of riparian zone		134	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.14/0.73/0.13	Moderate	0.5		
Cover (%)		1.3	***Poor***	***0.1***	2985.8	299
Percent pools (%)		1.7	Moderate	0.5		
Vegetation index of riparian zone		134	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1150

Watershed **South Teigen**

ILP **ILP 1150**

		Area 1				
Habitat Variable	**Description of Habitat**	**Value**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	ADULT					
Stream gradient (%)		3	High	1		
Cover (%)		14.9	***Moderate***	***0.5***	677.0	339
Percent pools (%)		5	***Moderate***	***0.5***		
Vegetation index of riparian zone		107	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		37.7	***Poor***	***0.1***	677.0	68
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.25/0.37/0.37	***Moderate***	***0.5***		
Cover (%)		14.9	***Moderate***	***0.5***	677.0	339
Percent pools (%)		5	***Moderate***	***0.5***		
Vegetation index of riparian zone		107	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.25/0.37/0.37	***Moderate***	***0.5***		
Cover (%)		14.9	***Moderate***	***0.5***	677.0	339
Percent pools (%)		5	***Moderate***	***0.5***		
Vegetation index of riparian zone		107	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Tribs 1206

Watershed **South Teigen**

ILP **ILP 1206**

		Area 1				
Habitat Variable	**Description of Habitat**	**Value**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	ADULT					
Stream gradient (%)		1	High	1		
Cover (%)		80	High	1		
Percent pools (%)		0	***Poor***	***0.1***	59.3	6
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		40	***Poor***	***0.1***	59.3	6
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.6/0.4	Low	0.25		
Cover (%)		80	High	1		
Percent pools (%)		0	***Poor***	***0.1***	59.3	6
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.6/0.4	Low	0.25		
Cover (%)		80	High	1		
Percent pools (%)		0	***Poor***	***0.1***	59.3	6
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1054

Watershed **North Treaty**

ILP **ILP 1054**

		Area 1				
Habitat Variable	**Description of Habitat**	**Value**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		70	High	1		
Percent pools (%)		0	***Poor***	***0.1***	209.4	21
Vegetation index of riparian zone		158	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		90	***Poor***	***0.1***	209.4	21
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.1/0.9	Poor	0.25		
Cover (%)		70	High	1		
Percent pools (%)		0	***Poor***	***0.1***	209.4	21
Vegetation index of riparian zone		158	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.1/0.9	Poor	0.25		
Cover (%)		70	High	1		
Percent pools (%)		0	***Poor***	***0.1***	209.4	21
Vegetation index of riparian zone		158	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1055

Watershed **North Treaty**

ILP **ILP 1055**

		Area 1				
Habitat Variable	**Description of Habitat**	**Value**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***Poor***	***0.1***	222.8	22
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		20	***Moderate***	***0.5***	222.8	111
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.8/0.2	Low	0.25		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***Poor***	***0.1***	222.8	22
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.8/0.2	Low	0.25		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***Poor***	***0.1***	222.8	22
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1056

Watershed **North Treaty**

ILP **ILP 1056**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		4	High	1		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***Poor***	***0.1***	65.7	7
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		75	***Poor***	***0.1***	65.7	7
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		4	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.25/0.75	***Poor***	***0.1***		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***Poor***	***0.1***	65.7	7
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		4	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.25/0.75	***Poor***	***0.1***		
Cover (%)		10	Moderate	0.5		
Percent pools (%)		0	***Poor***	***0.1***	65.7	7
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1057

Watershed **North Treaty**

ILP **ILP 1057**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	40.6	4
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		80	***Poor***	***0.1***	40.6	4
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.2/0.8	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	40.6	4
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.2/0.8	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	40.6	4
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1059

Watershed **North Treaty**

ILP **ILP 1059**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		3.7	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	1497.2	150
Vegetation index of riparian zone		115	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		74.2	***Poor***	***0.1***	1497.2	150
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.25/0.75	***Poor***	***0.1***		
Cover (%)		3.7	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	1497.2	150
Vegetation index of riparian zone		115	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.25/0.75	***Poor***	***0.1***		
Cover (%)		3.7	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	1497.2	150
Vegetation index of riparian zone		115	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1060

Watershed **North Treaty**

ILP **ILP 1060**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		13	Low	0.25		
Cover (%)		5	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	2535.1	254
Vegetation index of riparian zone		114	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		0	***High***	***1***	2535.1	2535
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		13	Low	0.25		
Substrate (% gravel and rubble(A/B/C))		0.9/0.1/0	High	1		
Cover (%)		5	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	2535.1	254
Vegetation index of riparian zone		114	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		13	Low	0.25		
Substrate (% gravel and rubble(A/B/C))		0.9/0.1/0	High	1		
Cover (%)		5	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	2535.1	254
Vegetation index of riparian zone		114	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1061

Watershed North Treaty

ILP ILP 1061

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		5	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	22.6	2
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		80	***Poor***	***0.1***	22.6	2
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.2/0.8	***Poor***	***0.1***		
Cover (%)		5	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	22.6	2
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.2/0.8	***Poor***	***0.1***		
Cover (%)		5	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	22.6	2
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1062

Watershed **North Treaty**

ILP **ILP 1062**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	***High***	***1***		
Cover (%)		28.6	***High***	***1***		
Percent pools (%)		40	***High***	***1***	293.2	293
Vegetation index of riparian zone		150	***High***	***1***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	***High***	***1***		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	***High***	***1***		
	EMBRYO					
Substrate (% fines)		20	***Moderate***	***0.5***	293.2	147
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.8/0.2	***Low***	***0.25***	293.2	73
Cover (%)		28.6	High	1		
Percent pools (%)		40	High	1		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.8/0.2	***Low***	***0.25***	293.2	73
Cover (%)		28.6	High	1		
Percent pools (%)		40	High	1		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1063

Watershed **North Treaty**

ILP **ILP 1063**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	10.5	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	10.5	1
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	10.5	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	10.5	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1064

Watershed **North Treaty**

ILP **ILP 1064**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	20.0	2
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		60	***Poor***	***0.1***	20.0	2
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.4/0.6	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	20.0	2
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.4/0.6	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	20.0	2
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1065

Watershed **North Treaty**

ILP **ILP 1065**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	44.9	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	44.9	4
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	44.9	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	44.9	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1066

Watershed **North Treaty**

ILP **ILP 1066**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	14.9	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	14.9	1
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	14.9	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	14.9	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1067

Watershed **North Treaty**

ILP **ILP 1067**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	141.8	14
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	141.8	14
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	141.8	14
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	141.8	14
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1068

Watershed **North Treaty**

ILP **ILP 1068**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	70.0	7
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	70.0	7
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	70.0	7
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	70.0	7
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1069

Watershed **North Treaty**

ILP **ILP 1069**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	4.8	0.5
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	4.8	0.5
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	4.8	0.5
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	4.8	0.5
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1070

Watershed **North Treaty**

ILP **ILP 1070**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	29.2	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	29.2	3
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	29.2	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	29.2	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1071

Watershed **North Treaty**

ILP **ILP 1071**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	13.0	1
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	13.0	1
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	13.0	1
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	13.0	1
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1072

Watershed **North Treaty**

ILP **ILP 1072**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	315.1	32
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		90	***Poor***	***0.1***	315.1	32
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	315.1	32
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	315.1	32
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1081

Watershed **North Treaty**

ILP **ILP 1081**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	106.9	11
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	106.9	11
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	106.9	11
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	106.9	11
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1082

Watershed **North Treaty**

ILP **ILP 1082**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		8.5	Low	0.25		
Percent pools (%)		5	***Poor***	***0.1***	1839.8	184
Vegetation index of riparian zone		126	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		51.3	***Poor***	***0.1***	1839.8	184
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.5/0.5	Low	0.25		
Cover (%)		8.5	Low	0.25		
Percent pools (%)		5	***Poor***	***0.1***	1839.8	184
Vegetation index of riparian zone		126	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.5/0.5	Low	0.25		
Cover (%)		8.5	Low	0.25		
Percent pools (%)		5	***Poor***	***0.1***	1839.8	184
Vegetation index of riparian zone		126	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1083

Watershed **North Treaty**

ILP **ILP 1083**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	54.8	5
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	54.8	5
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	54.8	5
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	54.8	5
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1084

Watershed **North Treaty**

ILP **ILP 1084**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	166.4	17
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		90	***Poor***	***0.1***	166.4	17
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.1/0.9	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	166.4	17
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.1/0.9	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	166.4	17
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1085

Watershed **North Treaty**

ILP **ILP 1085**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	57.9	6
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		10	***High***	***1***	57.9	58
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.1	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	57.9	6
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.1	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	57.9	6
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1086

Watershed **North Treaty**

ILP **ILP 1086**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		20	High	1		
Percent pools (%)		10	***Moderate***	***0.5***	97.3	49
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		10	***High***	***1***	97.3	97
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.7/0.3	Low	0.25		
Cover (%)		20	High	1		
Percent pools (%)		10	***Moderate***	***0.5***	97.3	49
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.7/0.3	Low	0.25		
Cover (%)		20	High	1		
Percent pools (%)		10	***Moderate***	***0.5***	97.3	49
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1087

Watershed **North Treaty**

ILP **ILP 1087**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		13.5	Moderate	0.5		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	246.7	25
Vegetation index of riparian zone		169	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		30	***Poor***	***0.1***	246.7	25
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		13.5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0/0.7/0.3	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	246.7	25
Vegetation index of riparian zone		169	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		13.5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0/0.7/0.3	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	246.7	25
Vegetation index of riparian zone		169	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1089

Watershed **North Treaty**

ILP **ILP 1089**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	36.0	4
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		100	***Poor***	***0.1***	36.0	4
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	36.0	4
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	36.0	4
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Tribs 1101

Watershed **North Treaty**

ILP **ILP 1101**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	7.0	1
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		10	***High***	***1***	7.0	7
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.1	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	7.0	1
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.1	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	7.0	1
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Main Reach 8

Watershed **South Teigen**

Reach **8**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		6	Moderate	0.5		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	4864.0	486
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		0	***High***	***1***	4864.0	4864
Average flow (% of MAF)	Fall	>50	High	1		
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		6	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		1.0/0/0	High	1		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	4864.0	486
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		6	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		1.0/0/0	High	1		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	4864.0	486
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Main Reach 6

Watershed **South Teigen**

Reach **6**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		5	Moderate	0.5		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	3896.0	390
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		52	***Poor***	***0.1***	3896.0	390
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0/0.48/0.52	Low	0.25		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	3896.0	390
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0/0.48/0.52	Low	0.25		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	3896.0	390
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Main Reach 5

Watershed **South Teigen**

Reach **5**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		1	High	1		
Cover (%)		26.8	High	1		
Percent pools (%)		25	***Moderate***	***0.5***	9871.3	4936
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		25.3	***Low***	***0.25***	9871.3	2468
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0.11/0.63/0.25	***Moderate***	***0.5***		
Cover (%)		26.8	High	1		
Percent pools (%)		25	***Moderate***	***0.5***	9871.3	4936
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0.11/0.63/0.25	***Moderate***	***0.5***		
Cover (%)		26.8	High	1		
Percent pools (%)		25	***Moderate***	***0.5***	9871.3	4936
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Main Reach 4

Watershed South Teigen

Reach 4

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		3	High	1		
Cover (%)		16	***Moderate***	***0.5***		
Percent pools (%)		21	***Moderate***	***0.5***	10891.0	5446
Vegetation index of riparian zone		123	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		7.9	***High***	***1***	10891.0	10891
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.56/0.35/0.08	***Moderate***	***0.5***		
Cover (%)		16	***Moderate***	***0.5***		
Percent pools (%)		21	***Moderate***	***0.5***	10891.0	5446
Vegetation index of riparian zone		123	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.56/0.35/0.08	***Moderate***	***0.5***		
Cover (%)		16	***Moderate***	***0.5***		
Percent pools (%)		21	***Moderate***	***0.5***	10891.0	5446
Vegetation index of riparian zone		123	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Main Reach 4 - Seep

Watershed **South Teigen**

Reach **4**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		3.5	High	1		
Cover (%)		38.2	High	1		
Percent pools (%)		22	***Moderate***	***0.5***	12304.4	6152
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		0	***High***	***1***	12304.4	12304
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		3.5	High	1		
Substrate (% gravel and rubble(A/B/C))		0.83/0.16/0	High	1		
Cover (%)		38.2	High	1		
Percent pools (%)		22	***Moderate***	***0.5***	12304.4	6152
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		3.5	High	1		
Substrate (% gravel and rubble(A/B/C))		0.83/0.16/0	High	1		
Cover (%)		38.2	High	1		
Percent pools (%)		22	***Moderate***	***0.5***	12304.4	6152
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Main Reach 2

Watershed North Treaty

Reach 2

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		2	High	1		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	9906.9	4953
Vegetation index of riparian zone		144	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		13.8	***High***	***1***	9906.9	9907
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.18/0.67/0.14	***Moderate***	***0.5***		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	9906.9	4953
Vegetation index of riparian zone		144	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.18/0.67/0.14	***Moderate***	***0.5***		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	9906.9	4953
Vegetation index of riparian zone		144	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Main Reach 1 -Seep

Watershed **North Treaty**

Reach **1**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		3	High	1		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	6358.0	3179
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	EMBRYO					
Substrate (% fines)		13.8	***High***	***1***	6358.0	6358
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	FRY					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.37/0.55/0.07	***Moderate***	***0.5***		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	6358.0	3179
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
	PARR					
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.37/0.55/0.07	***Moderate***	***0.5***		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	6358.0	3179
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

ST Wetlands - STW1

Watershed South Teigen

Wetland STW1

Habitat Variable	Life Stage	Area 1			
		Rating	HSI Value	Area (m^2)	HU
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		High	1	1,544	1544
	OVERWINTERING				
Habitat Quality		High	1	1,544	1544

NA = not applicable

ST Wetlands - STW3

Watershed South Teigen

Wetland STW3

Habitat Variable	Life Stage	Area 1			
		Rating	HSI Value	Area (m^2)	HU
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Low	0.25	309	77.25
	OVERWINTERING				
Habitat Quality		Low	0.25	309	77.25

NA = not applicable

NT Wetlands - NTW1

Watershed North Treaty

Wetland NTW1

Habitat Variable	Life Stage	Area 1			
		Rating	HSI Value	Area (m^2)	HU
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Poor	0.1	4,421	442.1
	OVERWINTERING				
Habitat Quality		Poor	0.1	4,421	442.1

NA = not applicable

NT Wetlands - NTW2

Watershed North Treaty

Wetland NTW2

Habitat Variable	Life Stage	Area 1			
		Rating	HSI Value	Area (m^2)	HU
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Poor	0.1	4,344	434.4
	OVERWINTERING				
Habitat Quality		Poor	0.1	4,344	434.4

NA = not applicable

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (MMER)

NT Wetlands - NTW3

Watershed **North Treaty**

Wetland **NTW3**

Habitat Variable	Life Stage	Area 1			
		Rating	HSI Value	Area (m^2)	HU
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Poor	0.1	624	62.4
	OVERWINTERING				
Habitat Quality		Poor	0.1	624	62.4

NA = not applicable

Appendix 6.3-1

HSI Ratings and Values for Compensation Sites (MMER)

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Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (MMER)

Watershed **Treaty**

Site **1**

Habitat Variable	Description of Habitat	Dolly Varden				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		1	High	**1**	4237	4237
Cover (%)		>30	High	1		
Percent pools (%)		40	High	1		
Vegetation index of riparian zone		>150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)	Assume optimal conditions	-	High	1		
Average dissolved oxygen (mg/L)	Assume optimal conditions	-	High	1		
Average pH	Assume optimal conditions	-	High	1		
	EMBRYO					
Substrate (% fines)		<15	High	**1**	4237	4237
Average flow (% of MAF)	Fall	>50	High	1		
Average velocity (cm/s)		~40	High	1		
Average temperature (ºC)	Assume optimal conditions	-	High	1		
Average dissolved oxygen (mg/L)	Assume optimal conditions	-	High	1		
Average pH	Assume optimal conditions	-	High	1		
	FRY					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0.4/0.5/0.1	Moderate	**0.5**	4237	2118.5
Cover (%)		>30	High	1		
Percent pools (%)		40	High	1		
Vegetation index of riparian zone		>150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)	Assume optimal conditions	-	High	1		
Average dissolved oxygen (mg/L)	Assume optimal conditions	-	High	1		
Average pH	Assume optimal conditions	-	High	1		
	PARR					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0.4/0.5/0.1	Moderate	**0.5**	4237	2118.5
Cover (%)		>30	High	1		
Percent pools (%)		40	High	1		
Vegetation index of riparian zone		>150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)	Assume optimal conditions	-	High	1		
Average dissolved oxygen (mg/L)	Assume optimal conditions	-	High	1		
Average pH	Assume optimal conditions	-	High	1		

NA = not applicable

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (MMER)

Watershed **Treaty**
Site **1**

Habitat Variable	Life Stage	All Ponds			
		Rating	HSI Value	Area (m^2)	HU
	MIGRATION				
Habitat Quality		NA	NA	-	4,237
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		High	1	153,825	153,825
	OVERWINTERING				
Habitat Quality		Excellent	0.75	153,825	115,369

NA = not applicable

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (MMER)

Watershed **Treaty**
Existing Site **1 - Pond**

		Pond 1			
Habitat Variable	**Life Stage**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Poor	0.1	240	24
	OVERWINTERING				
Habitat Quality		Poor	0.1	240	24

		Pond 2			
Habitat Variable	**Life Stage**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Poor	0.1	800	80
	OVERWINTERING				
Habitat Quality		Poor	0.1	800	80

		Pond 3			
Habitat Variable	**Life Stage**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Poor	0.1	200	20
	OVERWINTERING				
Habitat Quality		Poor	0.1	200	20

		Pond 4			
Habitat Variable	**Life Stage**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Above Average	0.75	700	525
	OVERWINTERING				
Habitat Quality		Moderate	0.5	700	350

		Pond 5			
Habitat Variable	**Life Stage**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Low	0.25	80	20
	OVERWINTERING				
Habitat Quality		Low	0.25	80	20

NA = not applicable

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (MMER)

Watershed **Treaty**
Existing Site **1 - Pond**

		Pond 6			
Habitat Variable	**Life Stage**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Moderate	0.5	225	112.5
	OVERWINTERING				
Habitat Quality		Low	0.25	225	56.25

		Pond 7			
Habitat Variable	**Life Stage**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Low	0.25	600	150
	OVERWINTERING				
Habitat Quality		Low	0.25	600	150

		Pond 8			
Habitat Variable	**Life Stage**	**Rating**	**HSI Value**	**Area (m^2)**	**HU**
	MIGRATION				
Habitat Quality		NA	NA	-	-
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Low	0.25	1,500	375
	OVERWINTERING				
Habitat Quality		Low	0.25	1,500	375

NA = not applicable

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (MMER)

Watershed **Treaty**

Existing Site **1 - Stream**

Habitat Variable	Description of Habitat	Dolly Varden				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT					
Stream gradient (%)		1	High	1	4237	
Cover (%)	ISD, Assume moderate/average conditions	-	Moderate	**0.5**	150	75
Percent pools (%)	ISD, Assume moderate/average conditions	-	Moderate	**0.5**		
Vegetation index of riparian zone		>150	High	1		
Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	**0.5**		
Average temperature (ºC)	Assume optimal conditions	-	High	1		
Average dissolved oxygen (mg/L)	Assume optimal conditions	-	High	1		
Average pH	Assume optimal conditions	-	High	1		
	EMBRYO					
Substrate (% fines)		100	Poor	**0.1**	4237	423.7
Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
Average temperature (ºC)	Assume optimal conditions	-	High	1		
Average dissolved oxygen (mg/L)	Assume optimal conditions	-	High	1		
Average pH	Assume optimal conditions	-	High	1		
	FRY					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	Poor	**0.1**	4237	423.7
Cover (%)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
Percent pools (%)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
Vegetation index of riparian zone		>150	High	1		
Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
Average temperature (ºC)	Assume optimal conditions	-	High	1		
Average dissolved oxygen (mg/L)	Assume optimal conditions	-	High	1		
Average pH	Assume optimal conditions	-	High	1		
	PARR					
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	Poor	**0.1**	4237	423.7
Cover (%)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
Percent pools (%)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
Vegetation index of riparian zone		>150	High	1		
Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
Average temperature (ºC)	Assume optimal conditions	-	High	1		
Average dissolved oxygen (mg/L)	Assume optimal conditions	-	High	1		
Average pH	Assume optimal conditions	-	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (MMER)

Watershed **Taft**

Site **1**

Habitat Variable	Description of Habitat	Coho Salmon				
		Value	Rating	HSI Value	Area (m^2)	HU
	ADULT MIGRATION					
Max. temperature (°C)	Assume optimal conditions	-	Excellent	**0.75**	1936	1452
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	1		
	SPAWNING/INCUBATION/EMERGENCE					
Max. temperature (°C)	Assume optimal conditions	-	Excellent	**0.75**	1936	1452
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	1		
Substrate (% gravel/cobble)		>50	Excellent	1		
Substrate (% fines)		<15	Excellent	1		
	REARING					
Max. temperature (°C)	Assume optimal conditions	-	Excellent	**0.75**	1936	1452
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	0.75		
Substrate (% gravel/cobble)		>50	Excellent	1		
Substrate (% fines)		<15	Excellent	1		
Percent canopy		35 to 85	Excellent	1		
Riparian zone index		>150	Excellent	1		
Percent pools		40	Excellent	1		
Percent pools with canopy		>60	Excellent	1		
Percent cover		>30	Excellent	0.8		
	OVERWINTERING					
Max. temperature (°C)	Assume optimal conditions	-	Excellent	**0.75**	1936	1452
Percent winter cover		30	Excellent	0.75		

NA = not applicable

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (MMER)

Watershed **Taft**

Site **1**

Habitat Variable	Life Stage	All Ponds			
		Rating	HSI Value	Area (m^2)	HU
	MIGRATION				
Habitat Quality		NA	NA	-	4,237
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		High	1	44,673	44,673
	OVERWINTERING				
Habitat Quality		Excellent	0.75	44,673	33,505

NA = not applicable

Appendix 6.3-2

Technically Feasible Design Memo – Treaty Creek Site 1 (MMER)

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Draft Memorandum

DATE: December 2012 Refer to File No.: B.1_Treaty Creek Report.docx

SUBJECT: Treaty Creek: Feasibility Assessment of the Proposed Fish Habitat Compensation Area

1. Introduction

This report provides the results from the feasibility assessment for the proposed Fish Habitat Compensation Area within the Treaty Creek Watershed. The work has been focussed on the engineering planning and development of a new off-channel habitat system that is proposed along Treaty Creek.

The proposed Treaty Creek Fish Habitat Compensation Area (the Project) is located along the east side of the Treaty Creek valley, immediately downstream of the confluence with North Treaty Creek. Treaty Creek flows southeast discharging into the Bell-Irving River. The proposed Project is located on provincial Crown Land.

This report includes a description of the methodologies that were used in the feasibility assessment work. A results and observations section follows that describes the findings from the investigative work as well as identified risks to the development of the Project. Based on the completed technical feasibility assessment, conclusions and recommendations are provided for the development of the Project.

All figures, drawings, and plates are provided in appendices of this report.

2. Methodology

Field investigations were conducted during field trips in 2011 and 2012. Extensive ground and helicopter-based aerial observations were conducted during all field visits. The work in 2011 was focused on site assessments for locating the Project, as well as obtaining local topographic survey-based information at key locations along the route. Investigations in 2011 and 2012 were associated with developing an understanding of the hydrologic characteristics of the drainage basin, the geomorphology of Treaty Creek and North Treaty Creek, the subsurface materials, groundwater, as well as designing the layout of the proposed fish habitat compensation system.

A range of survey techniques were employed to collect local topographic data at locations across the proposed habitat compensation area. Differential GPS (DGPS) equipment was used to collect mapping grade topographic data and to collect feature data along the alignment. Compass and chain surveys were also used to collect additional topographic data across noted terrain features, and to further refine the DGPS data where necessary. Total station surveys were conducted at potential highway crossings and intake locations. In addition, field observations and aerial reconnaissance were conducted during all field visits.

Light Detection and Ranging (LiDAR) data was provided for the proposed fish habitat compensation area. The LiDAR data was utilized to develop a digital terrain model (DTM) for the area. The model also provided the basis for the engineering layout and development of the channel and pond system.

In 2011 and 2012, geomorphological assessments of the Project Area were carried out by completing a series of site investigations of local geologic terrain and channel conditions. This process also included an examination of historic aerial photographs and satellite imagery for Treaty Creek and North Treaty Creek.

A hydrometric station (STWM-H1) has been in operation in North Treaty Creek since 2008. The station was initially positioned immediately upstream of the confluence with Treaty Creek. During the fall of 2011, the monitoring station was re-located to an upstream location due to a channel avulsion that caused the abandonment of the previously monitored reach. Flow discharge measurements and hydrometric levelling surveys at the station have been completed in accordance with the *Manual of Hydrometric Standards in British Columbia* (RISC 2009).

Groundwater discharge zones were identified during the completion of local ground inspections in 2011 and in 2012 including observations of open water during winter periods. In June of 2012 three standpipes were installed along the proposed alignment to monitor groundwater levels. A series of active and abandoned beaver ponds are present along the toe of the hillslope at the downstream half of the Project. The terrain increases in gradient along the upstream half of the Project Area as the alignment extends up the alluvial fan. Shallow (~1 m deep) test pits were excavated by hand in 4 locations along the proposed alignment. Soils varied from coarse to fine sand with some silts and clays to sub-angular cobbles and boulders at surface.

3. Results and Observations

The results of the field investigations, office-based data review, and feasibility assessment are provided below. The information was used in the development of the proposed Fish Habitat Compensation area.

This section describes two separate creeks, North Treaty Creek and Treaty Creek. The Project is bound to the north by North Treaty Creek and to the west by Treaty Creek. The surface water intake for the Project will be off of North Treaty Creek. The upstream extent of the Project will be located on the North Treaty Creek alluvial fan and the remainder of the Project will be located on a mid-bench floodplain of Treaty Creek.

3.1 Basin Description

The Project is located in the floodplain of Treaty Creek downstream of its confluence with North Treaty Creek, a tributary of Treaty Creek. The proposed surface water intake location is located on North Treaty creek. The North Treaty Creek basin area is 33 km^2 and discharges into Treaty Creek approximately 15 km upstream of the confluence of Treaty Creek and the Bell-Irving River. The watershed area of Treaty Creek is 425 km^2, 26% of which is glaciated.

Vegetation within the Project area varies from a mixed mid-bench floodplain forest of cottonwood, spruce, and fir to willow, alder or sedge ecosystems. Soils included sand with some silts and clays in areas with little slope such as abandoned beaver ponds, sands and cobbles in areas closer to Treaty Creek, and colluvium near bedrock outcrops at the toe of the slope.

3.2 Channel Geomorphology

North Treaty creek is a steep mountainous creek that originates in a mid-elevation wetland complex. Tributaries of North Treaty Creek originate in steep glaciated alpine valleys that contribute significant sediment to the system. Average channel gradient for North Treaty Creek is 4% and the morphology of the channel is predominantly cascade-pool with channel bank-full widths ranging from 8 to 20 m. The channel is confined by bedrock at the proposed intake location and incised into the alluvial fan as it

approaches its confluence with Treaty Creek. The Project starts at the apex of the North Treaty Creek alluvial fan. This fan extends from the hill slope defining the Treaty Creek valley down to the confluence with Treaty Creek. The fan confines Treaty Creek to the west side of the valley.

The reach of Treaty Creek within which the Project is located exhibits braided river floodplain morphology (Knighton 1998). Channel bank-full widths of Treaty Creek range from 50 to 100 m along the reach within which the Project is proposed. Sediment transport processes are bedload driven, with in-channel depositional features ranging between lateral and point gravel bar deposits to elongated mid-channel gravel bars within the stream. Jams of large woody debris are also present along the channel margins or stranded on gravel bars. The portion of the floodplain within which the Project is located shows no sign of recent occupation, with the stand of trees in the mid-bench ecosystems between Treaty Creek and the Project being 80 to 120 years old or greater.

3.3 Hydrology

Surface water flows are generated from hillslope-related runoff from precipitation events, as well as snow melt and glacier melt. Hydrometric stations have been in place at North Treaty Creek for 4 years and Treaty Creek for 2 years. Based on these data the mean annual discharge (MAD) for North Treaty Creek was estimated at 1.4 m^3/s and the average peak daily discharge for the period of record is 10.5 m^3/s. The MAD for Treaty Creek was estimated at 32.8 m^3/s, with an average peak daily discharge of 229.4 m^3/s.

For North Treaty Creek, the estimated annual hydrograph is characterized by spring meltwater flows that begin in mid-April. Freshet-induced peak flows occur late May or early June. Surface water flows decline throughout the summer months as contributions from snowpack and hillslope-related runoff decrease. During the fall period, the annual hydrograph features peak discharge events that occur in response to intense rainfall-runoff events. Winter low flow conditions tend to develop by mid-November and continue until spring freshet (Figure 4).

Given a potential withdrawal rate of 10% of daily discharge, there would be insufficient flow in North Treaty Creek during low flow seasons to support a habitat compensation project on surface water alone. Surface water can be used to augment groundwater supply during the open water season. Habitat areas in ponds and channels will be scaled such that no greater than 10% MAD would be diverted to support them.

3.4 Engineering Planning

The preliminary design of the proposed fish habitat compensation area consists of a series of 9 ponds and interconnecting channels providing 158,062 m^2 of wetted area, fed primarily by groundwater. The purpose of the channels and ponds is to provide off-channel rearing, refuge and overwintering habitat. The Project is located on the east side of the Treaty Creek valley. Nine proposed ponds are connected by 10 channel sections positioned along the toe of the hillslope that confines the Project to the east. The Project will extend down valley parallel to Treaty Creek and flow out into an existing pool that drains into main channel (Appendix B, Drawing KSM-TRC-012-013).

The ponds and channels presented in the preliminary design drawings represent generic shapes that will be further developed during the detailed design phase. During the detailed design phase, additional complexity and specific habitat features will be prescribed such as pool-riffle morphology, shoal-island-deepwater complexing in ponds, LWD placement frequency and orientation, and riparian prescriptions including low-bank wetland vegetation (Appendix B, Drawing KSM-TYP-012-026).

The following is a summary of the results from the completed engineering planning and assessment work that were used in the preliminary design phase:

- The design of the Project is based on the concept that open channels and ponds will be excavated below the existing ground surface to intercept groundwater and seasonal surface water runoff from the adjacent landscape.
- Design criteria for the layout and dimensions of the ponds and open channels were derived from the spatial limitations of the site, channel and pond stability, habitat features, and habitat area required for compensation.
- The channel patterns and the configuration of the ponds were based on the existing ground contours and were designed to integrate the ponds into the surrounding landscape to minimize earthworks construction volumes.
- The trapezoidal shape and size of the open channel sections were sized to convey any intercepted ground and surface waters along the ponds and channel sections. The channel base width is 2 m, with 2H:1V sideslopes excavated to depths up to 2 m below the existing ground surface.
- An average design flow of 0.1 m^3/s was used for planning purposes with the minimum water depth along the channel sections to be 0.3 m. This will result in an average stream velocity of 0.12 m/s^2.
- The outlet for the Project will be located downstream along the left bank of Treaty Creek discharging into an existing natural pond that is connected to Treaty Creek. The outlet will also serve as the access point for fish to enter the Project.
- A proposed surface water intake location was identified along the left bank of North Treaty Creek. Surface water may be supplied to the Project if insufficient groundwater exists.
- Based on an estimated MAD value of 1.4 m^3/s, a 10% MAD value of 0.14 m^3/s could be extracted from North Treaty Creek. This volume would augment the groundwater and improve water quality.
- The design criterion for the depths of the ponds was determined by the need to provide ice-free overwintering habitat. The maximum winter ice thickness, as determined by winter ice core sampling in existing Treaty Creek ponds was 1.0 m. The design proposes that 50% of the area of each pond will be >2 m deep as measured from the outlet channel invert.
- Deeper water sections 3 to 4 m deep will be present within each pond. The depths of these sections will be determined, in part, by the minimum elevation of the local water table at each location.
- An access road and protection dyke will be constructed along the western extent of the Project. This embankment structure will be sized to withstand a 25 year flood event and will provide access during the construction and future maintenance of the Project. The structure will be constructed from materials excavated during the construction of the ponds and channels.

3.5 Risk Assessment

As part of the feasibility assessment for the proposed Project, a risk assessment was undertaken to identify information gaps and to quantify potential risk. The assessment was based on the available information and included an assessment of the water supply potential, channel stability, earthworks, the layout of the proposed system, and related maintenance requirements.

During the risk assessment all available information was reviewed, significant information gaps were identified, any hazards associated with the known information or with gaps were considered. Possible consequences associated with the information or information gaps were then identified and a risk rating relative to the feasibility the project was assigned. Finally, potential mitigation for associated risks was identified.

The risk assessment results are provided in Appendix D. The following is a summary of the risk assessment.

3.5.1 Water Supply

- The supply of surface water from North Treaty Creek is not considered to be sufficient for year round use. It is likely that during spring freshet and fall rains higher flows can be extracted and supplement the existing groundwater supply. Ongoing hydrometric monitoring will continue in order to refine mean annual discharge estimate.
- Based on the evidence of groundwater presence along the proposed route throughout the year, it is expected that sufficient groundwater sources will be available and can be augmented by the available surface water from North Treaty Creek.
- Length and depth of groundwater collection channel to be determined to provide flow rates for channel design.

3.5.2 Channel Stability

- Channel stability is moderate along North Treaty Creek at the proposed water intake location due to exposed bedrock banks and its position relative to the proposed bridge crossing; The proposed intake location is at the apex of the fan, and is in the location of a proposed bridge crossing.
- Flooding potential along some downstream sections of the Project area along Treaty should be evaluated during the final design process for the location of the drainage outlet and any related protection work; No evidence of recent channel occupation was noted in either the historic aerial photos or the field.
- The access road/protection dyke will be sized to protect the Project from a 25 year event

3.5.3 Earthworks Construction

- An abundance of well-graded coarse-grained materials indicates suitable materials for constructing the access road/protection dyke and for use as channel substrate.
- Additional resources will be further identified during subsurface investigations prior to finalizing detailed designs.

3.5.4 Project Layout

- The Project layout incorporated the North Treaty alluvial fan to provide protection from Treaty Creek, the proposed North Treaty bridge crossing will provide additional stability for the intake structure, and the hillslope will also provide lateral stability along its eastern extent.
- Channel sections were maintained at 1 to 3 % gradients to provide suitable habitat for target species and be within the gradient range for pool-riffle and forced pool-riffle morphologies.
- Ponds were laid out along contours and within other landscape features to minimize earthworks.
- Design of the water intake will require protection against local aggradation and degradation. It will be designed to exclude most sediment and the first pond in the system will act as a grit pond for removing suspended sediment.

3.5.5 Maintenance Requirements

- Maintenance needs were evaluated to be at a moderate risk for beaver-related impacts, low risk for sediment accumulation, and low risk for physical repairs to pond and channel sections and debris obstructions.

- Active wildlife management will likely be required on an annual basis to mitigate the potential effects of beaver activities within the compensation area.
- Outlet locations will be properly positioned and maintained to ensure continuation of fish access.
- Proximity to the proposed access road allows for good access for maintenance.

4. Conclusions and Recommendations

The results from the feasibility assessment for the proposed Fish Habitat Compensation Area along Treaty Creek have been presented. Site investigation and engineering planning has been completed to confirm that the development of the Project area is technically feasible at the location. The low gradient terrain indicates that conventional excavation and construction techniques for the channels and ponds will be appropriate.

The presence of groundwater along the proposed route layout indicates a high potential for groundwater to be the primary water supply source for the compensation network. North Treaty Creek contains sufficient flows to augment the water supply to the Project. The existing terrain provides suitable low gradient ground surfaces for the construction of the channels and ponds. The layout of the compensation area is well positioned relative to the location of the Treaty Creek active channel sections.

The designs presented in Appendix B show potential habitat area that is feasible to construct. The actual areas that will be constructed will be less than these potential areas and will be determined based on the habitat area required for sufficient compensation. The larger potential number is presented as optional area available as a risk mitigation measure.

The Project was chosen based on many biological and geophysical criteria. However, operationally, the proximity to existing or planned road infrastructure and the area available in the Treaty watershed made this site suitable. Preference was given to building fewer larger projects as opposed to many small projects in order to more efficiently use resources and to focus maintenance activities.

Wetland habitat compensation is an additional component of the larger KSM habitat compensation program. Wetland habitat will be developed within the Project and wetland scientists have participated in the design of the Project to ensure both habitat types are included in the design. The combination of both fish and wetland habitat development is a natural corollary and will ensure an inclusive ecosystem approach to the development of the Project. The typical pond detail in Appendix B shows some examples of ecosystem complexing that will be implemented.

The Projects represent relatively large-scale construction activities and may require multiple years to make fully operational. As such, a staged approach to the construction of these Projects is recommended. This approach would allow for seasonal settling and stabilization, integration of regulator and stakeholder participation, design changes as required by site conditions, and sufficient flexibility to incorporate the Projects into the surrounding landscape while minimizing impacts to the existing ecosystems.

The following recommendations are put forward for consideration in the future development of the Project.

1. The established surface water and groundwater monitoring programs should be continued so that the water sources are properly characterized for use in detailed design.
2. Detailed engineering surveys should be completed along the proposed alignment.

3. Based on the completed surveys, detailed design work is required to determine the final configuration of the channels, ponds, and access road/protection dyke.
4. Hydraulic modeling should be completed to assess the functioning of the systems and the effect of habitat complexing on flow velocity distributions and water quality conditions across representative channel sections and ponds. In addition, detailed hydraulic scour analyses and channel bank protection requirements should be conducted with respect to Treaty Creek.
5. A hazard analysis should be completed based on the existing flood frequency analysis to determine the design flood levels across the Project and where additional embankment protection is required.
6. The construction-related earthwork volumes should be determined as well as a cost estimate for the construction of the Project.
7. A Construction Management Plan should be completed that will include road access details, borrow and spoil areas, material handling, construction sequencing, and an Environmental Management Plan for the Project area.

References

Knighton, A.D. 1998. Fluvial Forms and Processes: A New Perspective. Routledge, New York.

Resources Information Standards Committee, Ministry of Environment (RISC). 2009. Manual of British Columbia Hydrometric Standards.

- Appendix A -

Figures

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PROJECT # 868-020-04-02 GIS No. KSM-10-169a November 7, 2012

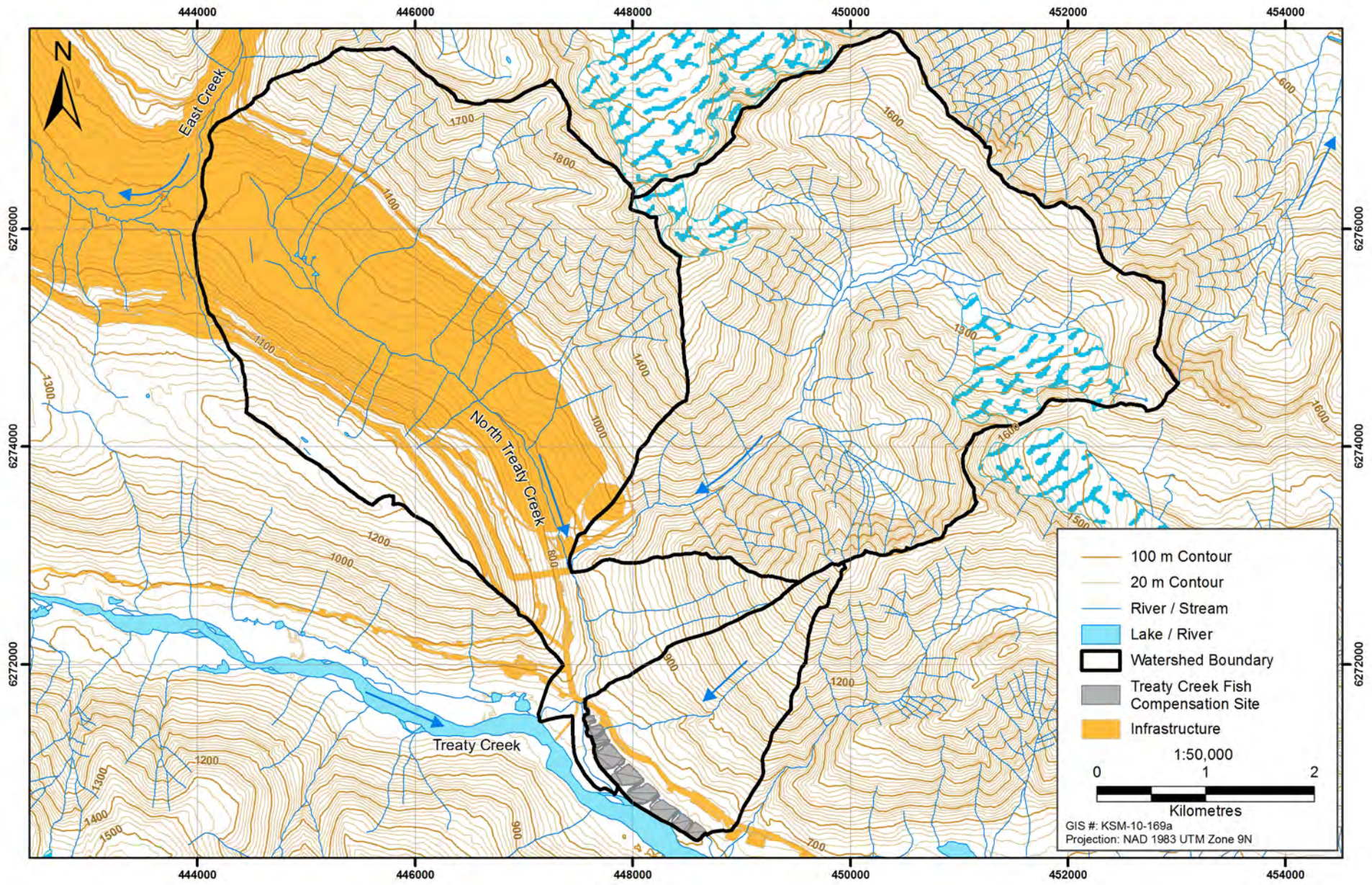

Figure 1

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KSM PROJECT

Drainage Area for Treaty Creek Watershed

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PROJECT # 868-020-04-02 GIS No. KSM-10-166a November 7, 2012

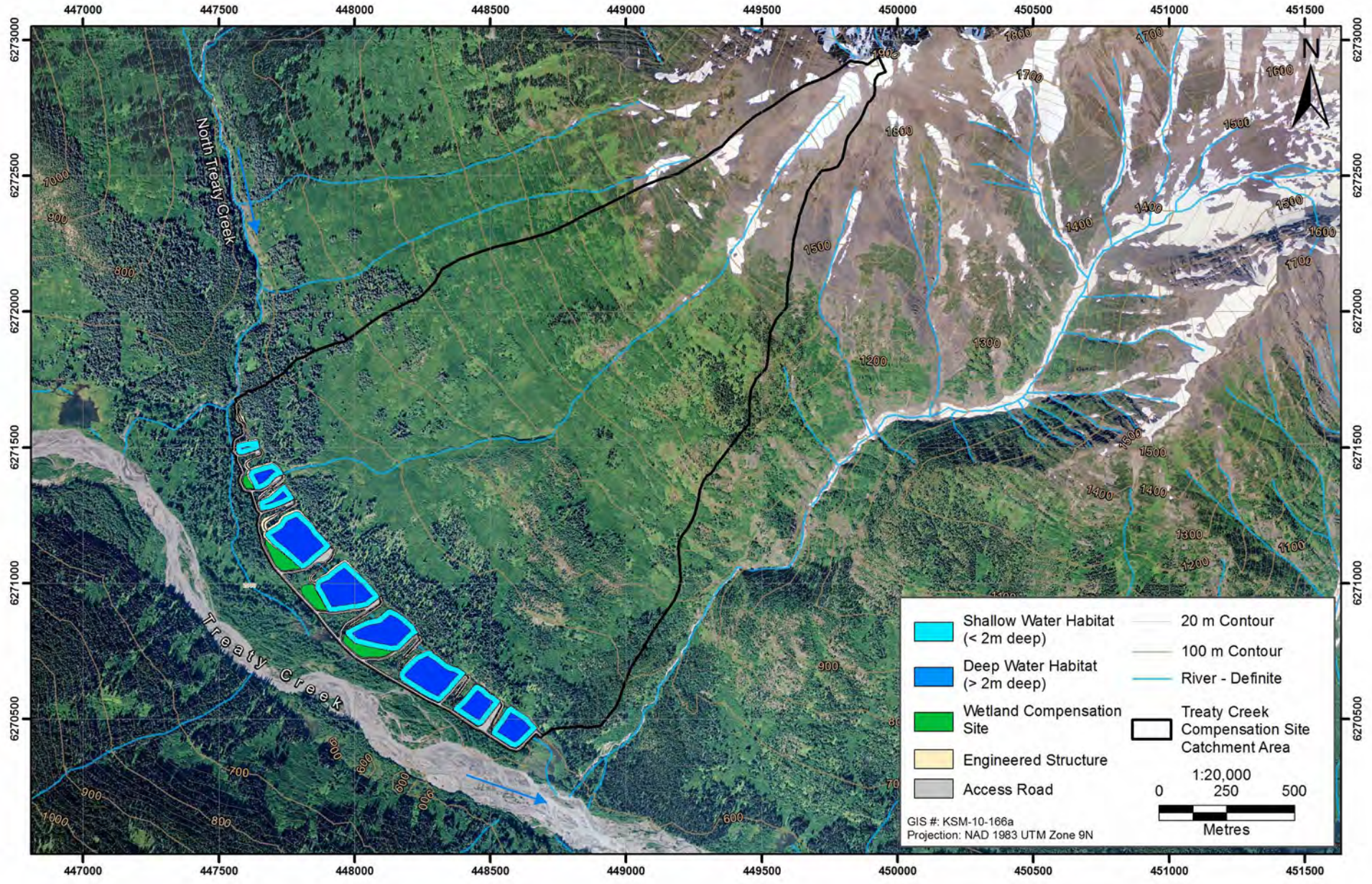

Figure 2

SEABRIDGE GOLD
KSM PROJECT

Drainage Area for the Proposed Treaty Creek Fish Habitat Compensation Area

Figure 2

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Figure 3

Treaty Creek Fish Habitat Compensation Area Overview

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KSM PROJECT

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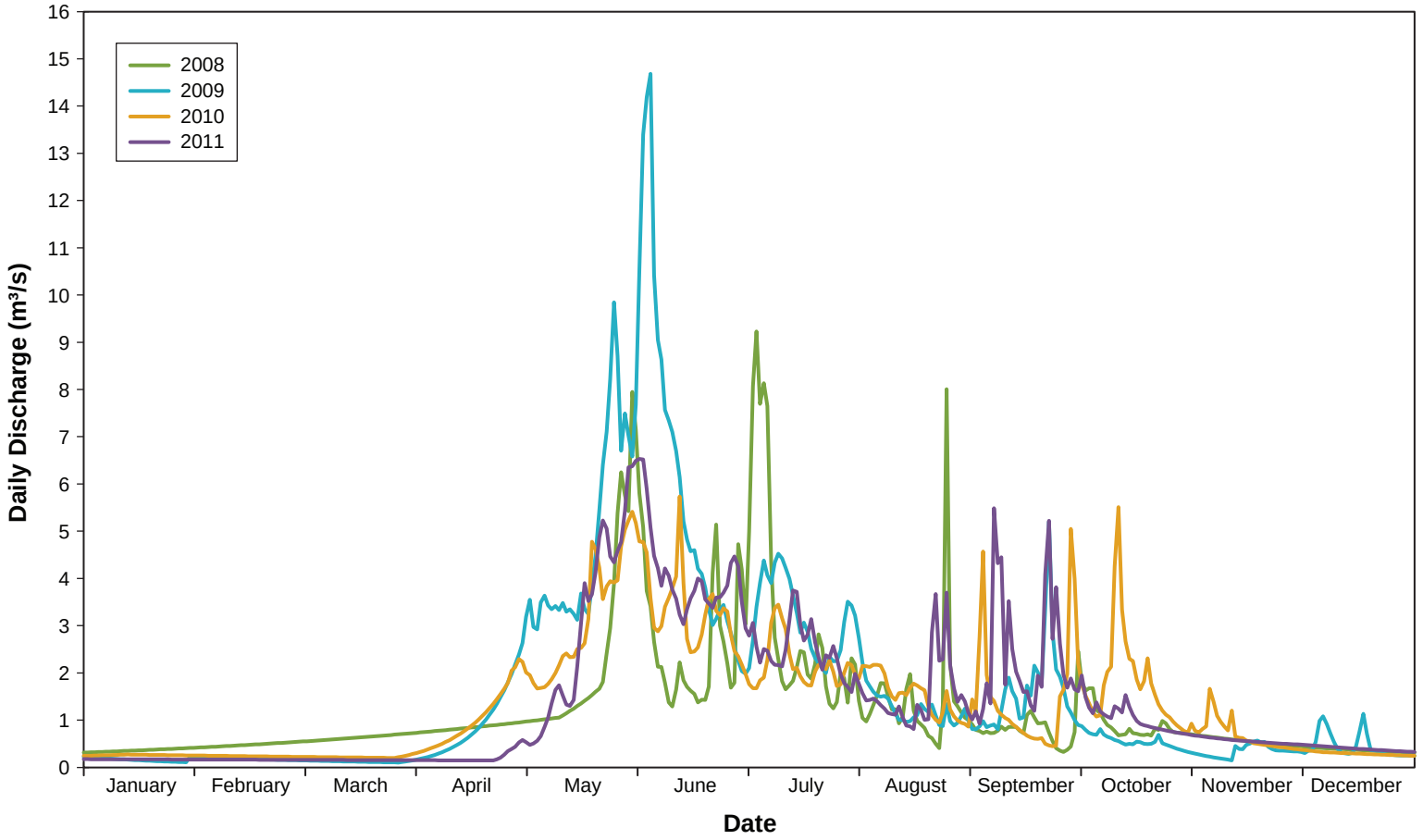

Figure 4

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KSM PROJECT

Annual Hydrograph at Hydrometric Station STWM-H1, North Treaty Creek, 2008 to 2011

Figure 4

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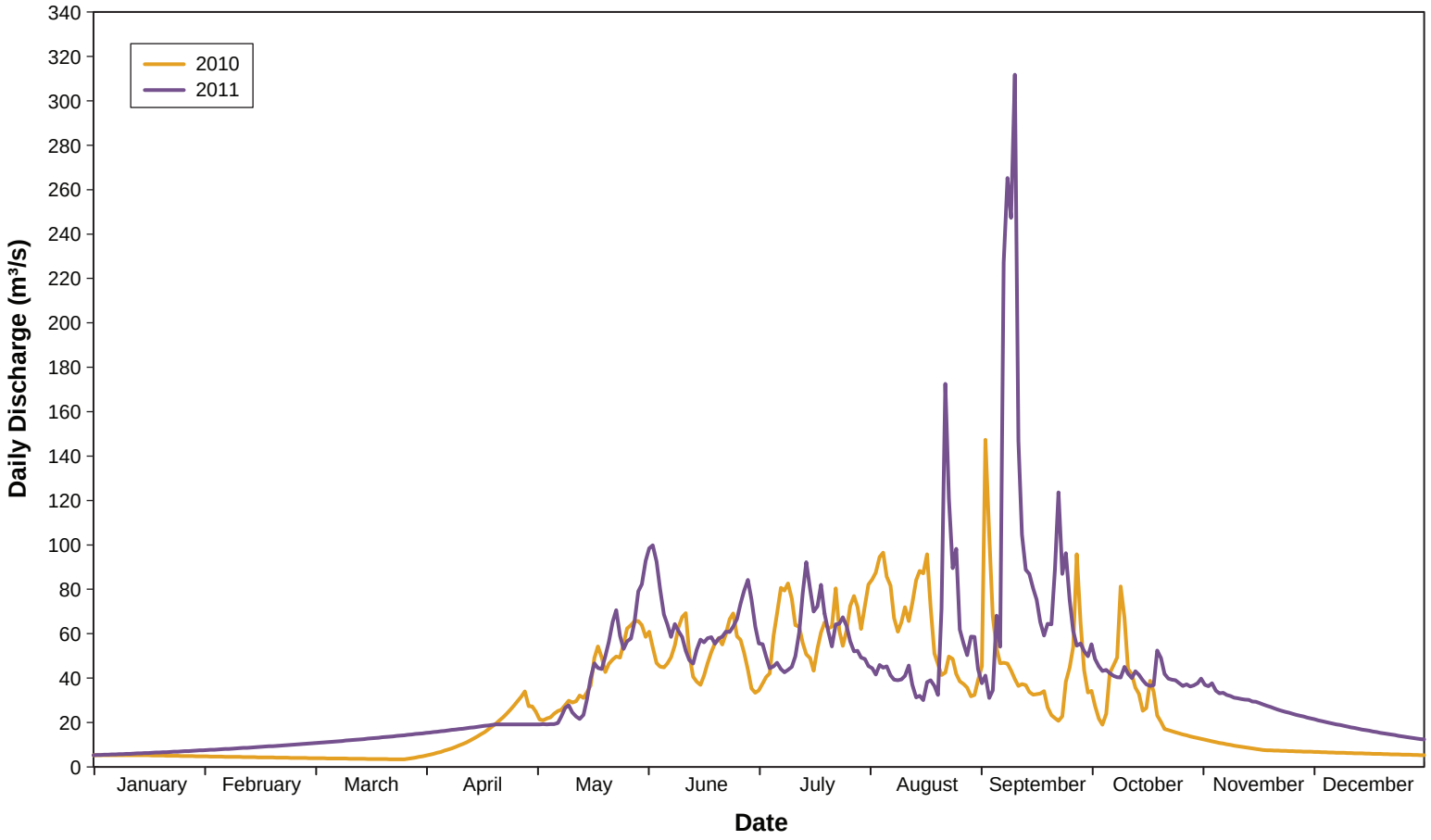

Figure 5

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Annual Hydrograph at Hydrometric Station TC-H1, Treaty Creek, 2010 to 2011

Figure 5

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- Appendix B -

Drawings

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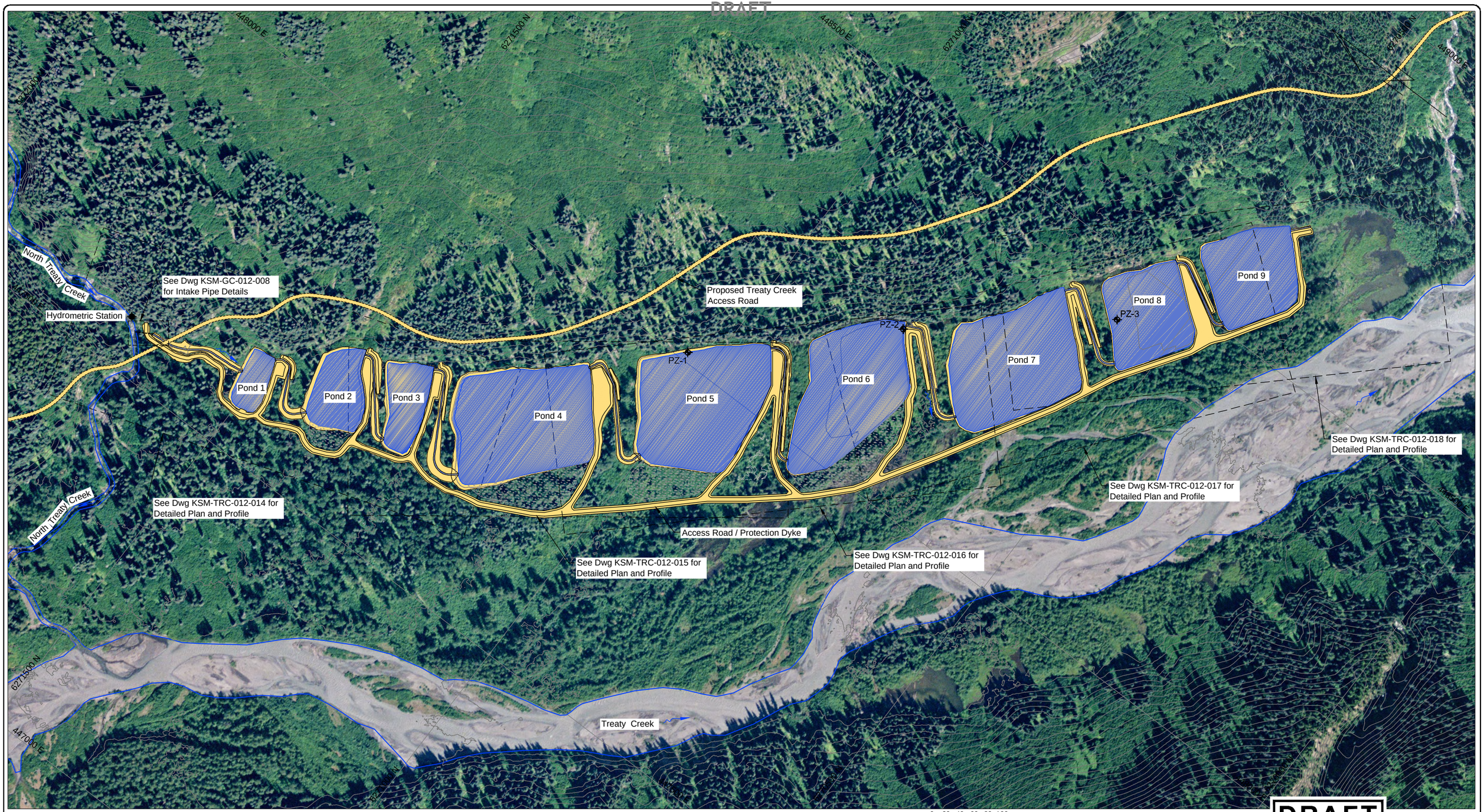

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B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	8Aug12

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SCALE: as shown

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CAD/GIS No: KSM-TRC-012-013a

DATE: Sept. 28, 2012

TITLE:

Treaty Creek Overview

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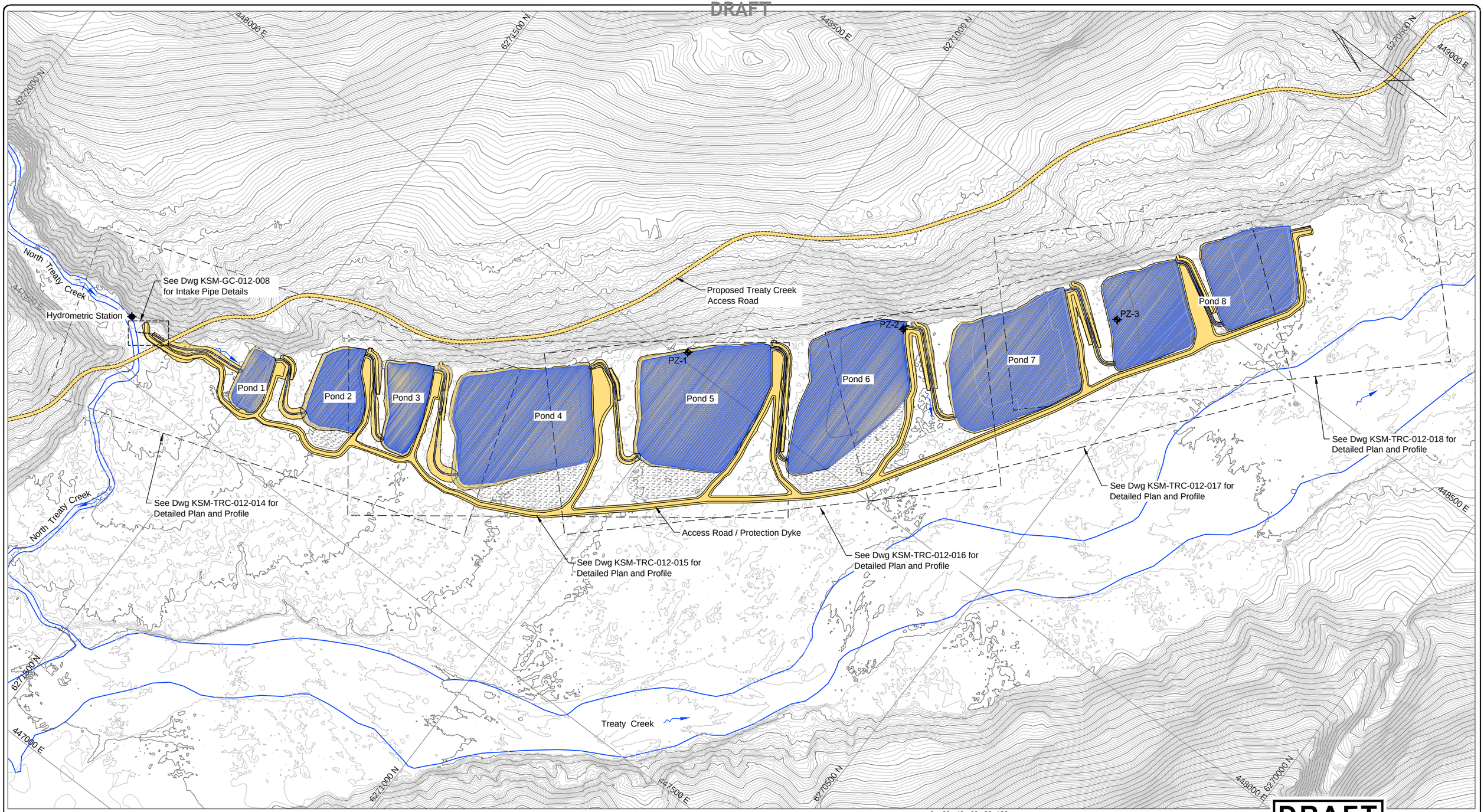

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CAD/GIS No: KSM-TRC-012-013

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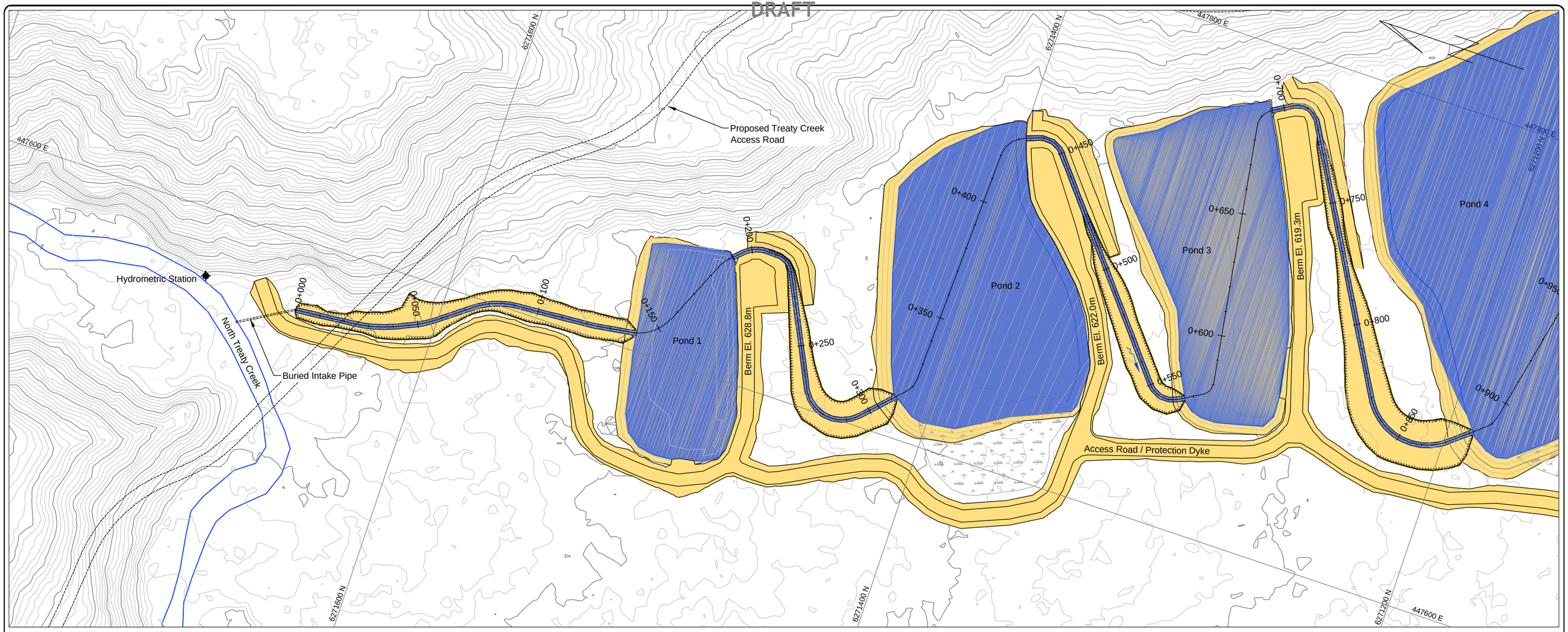

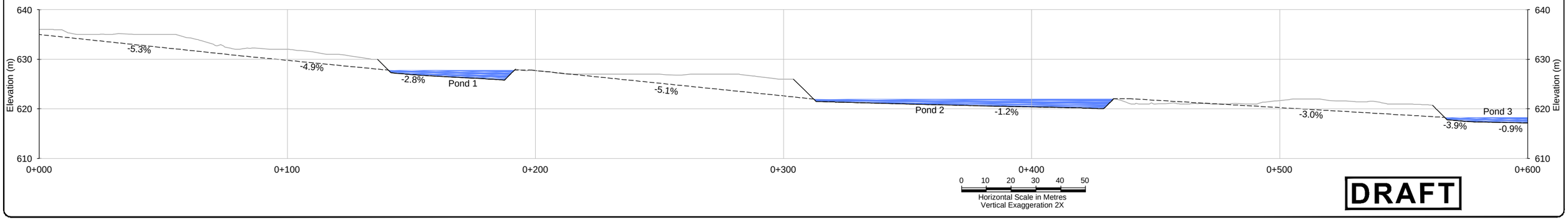

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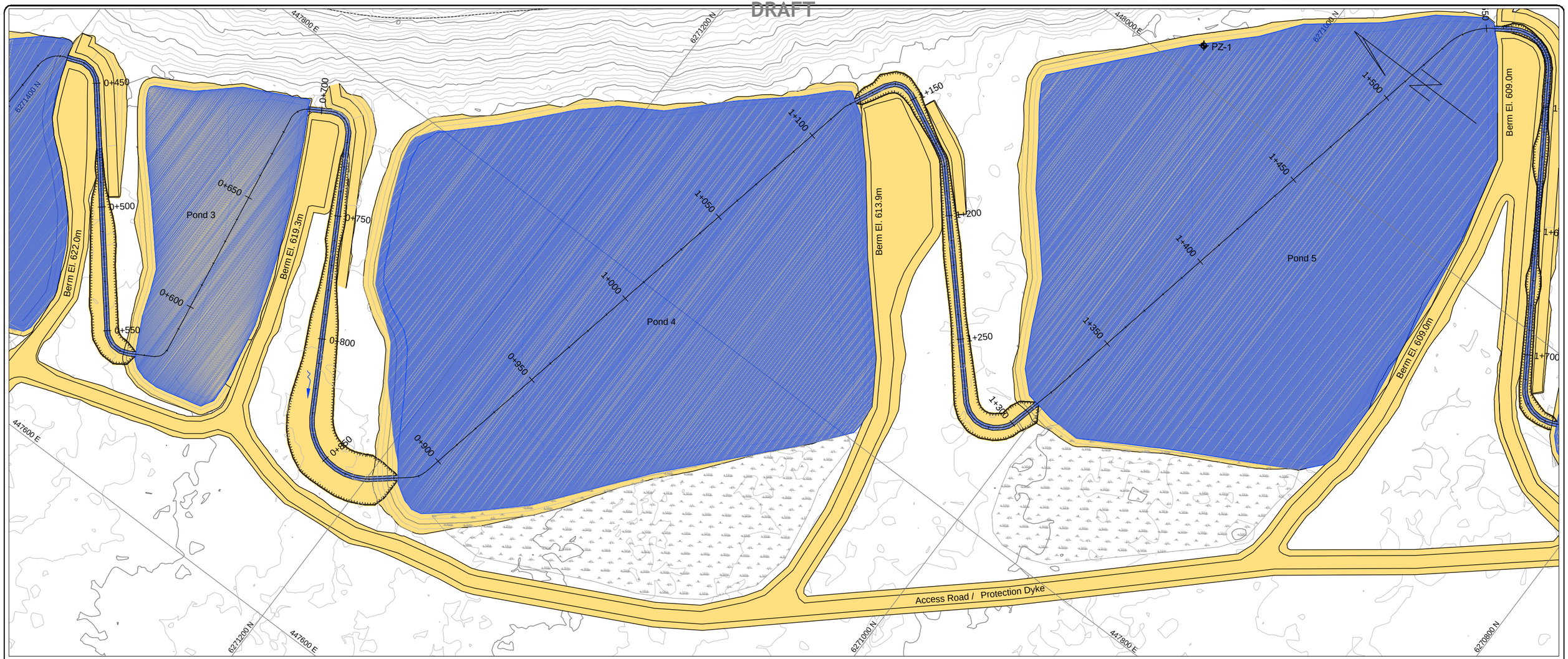

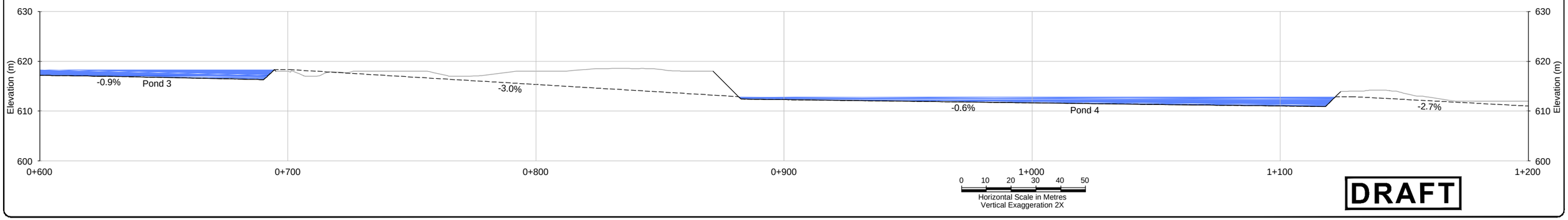

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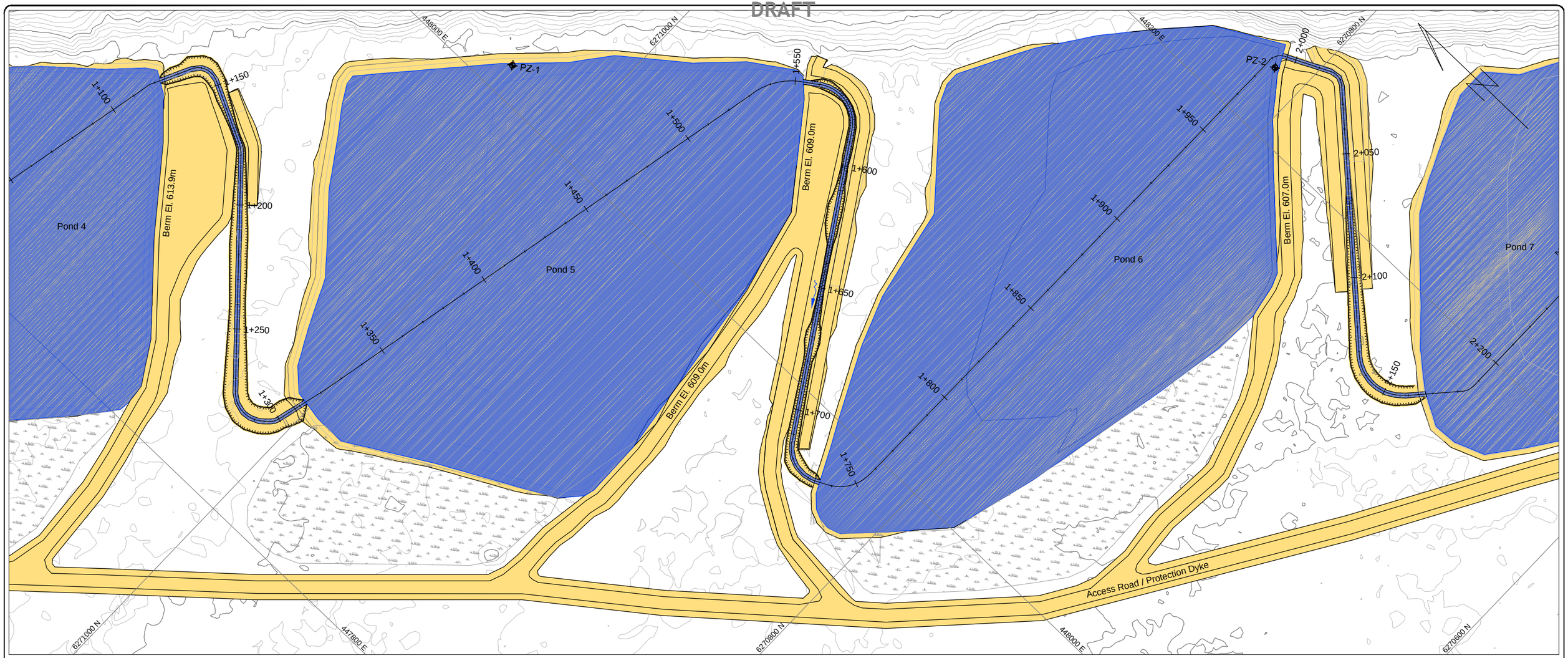

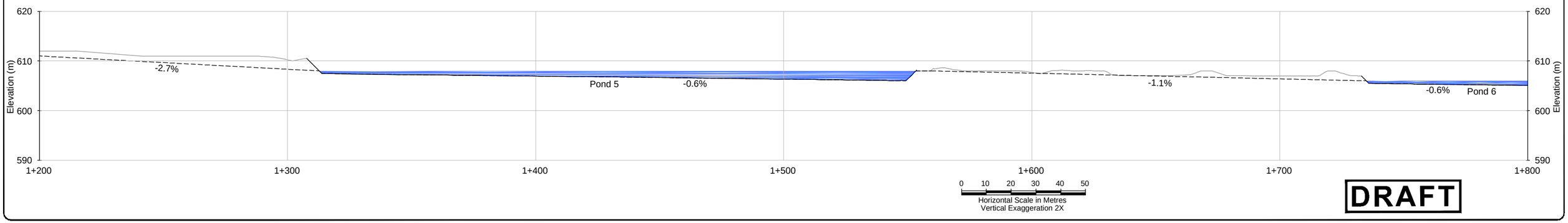

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DATE: Sept. 28, 2012

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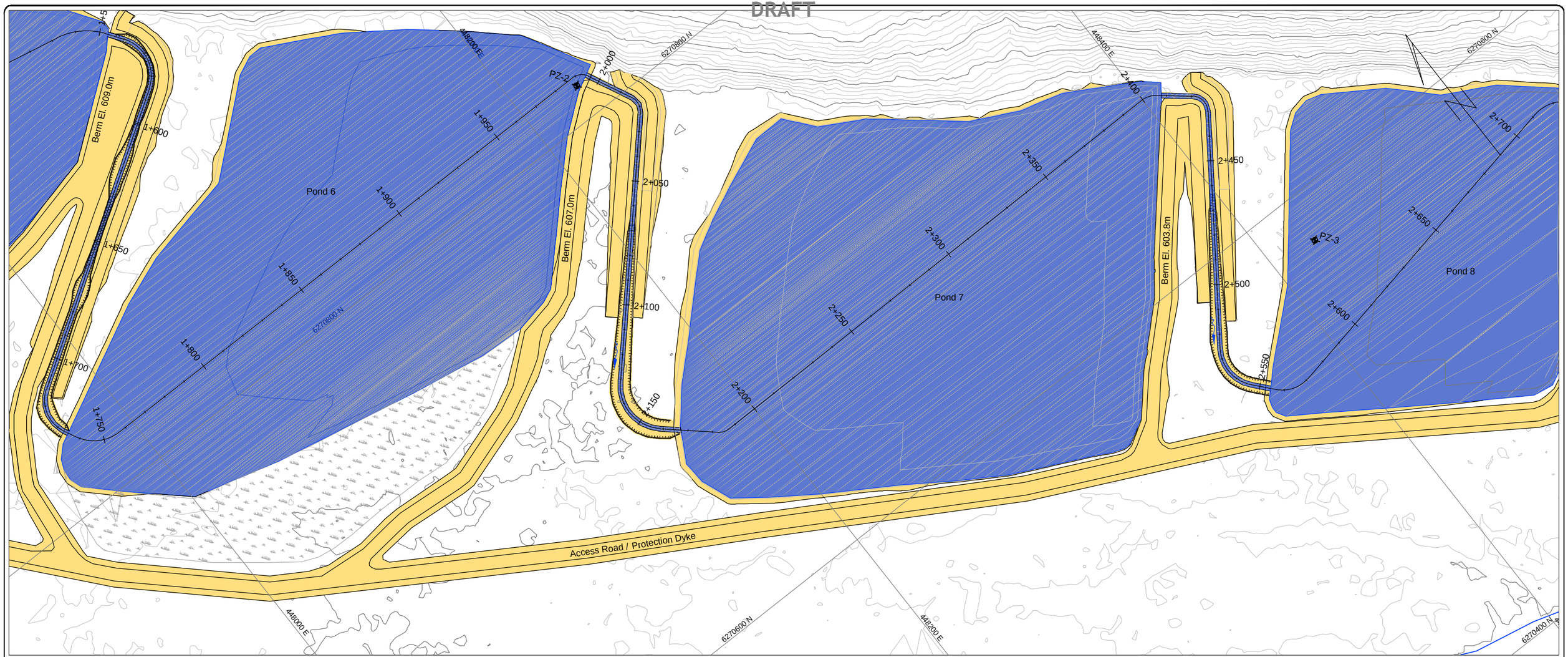

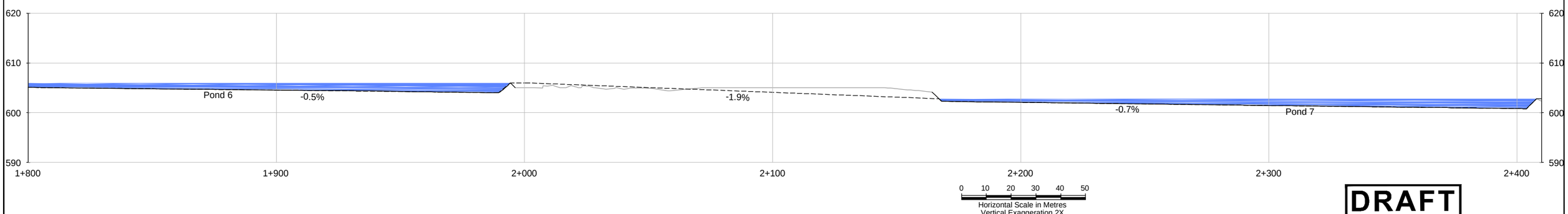

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A	Issued for Discussion	DG	BA	8Aug12

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DATE: Sept. 28, 2012

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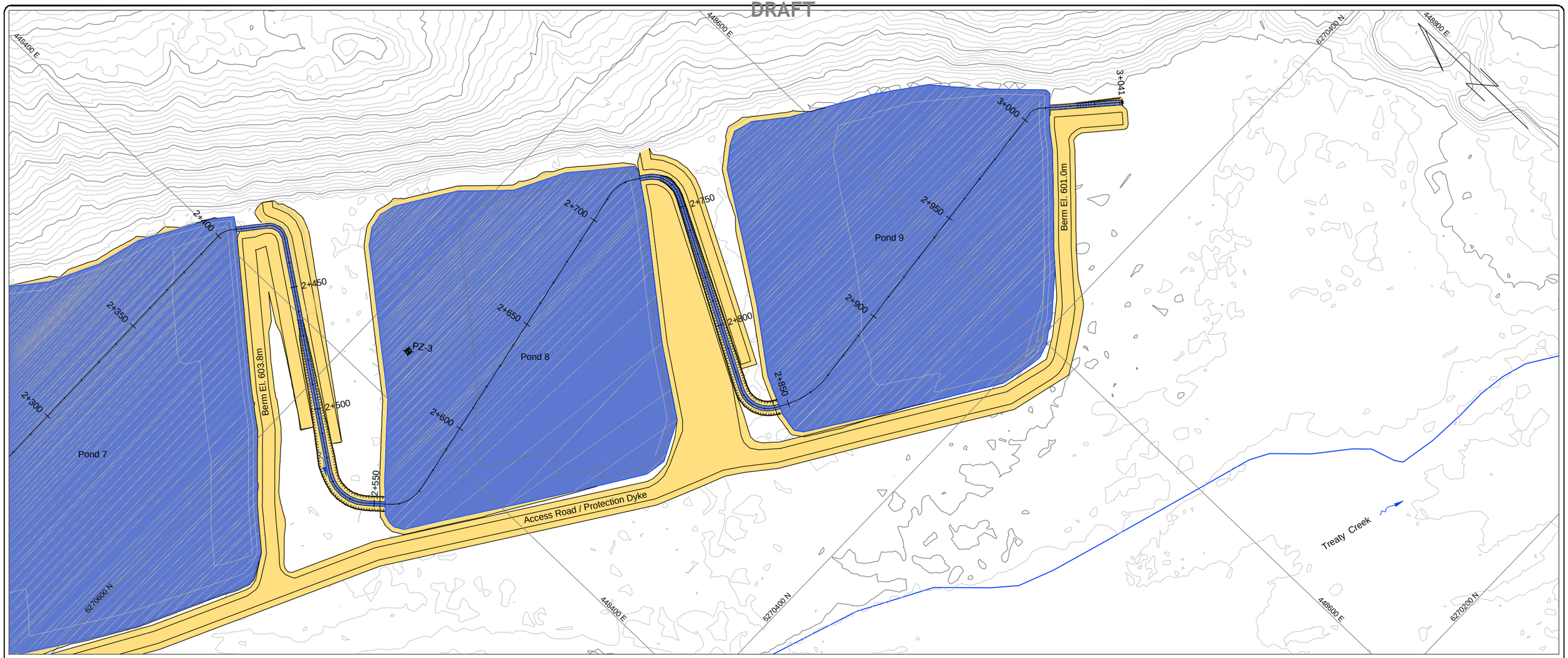

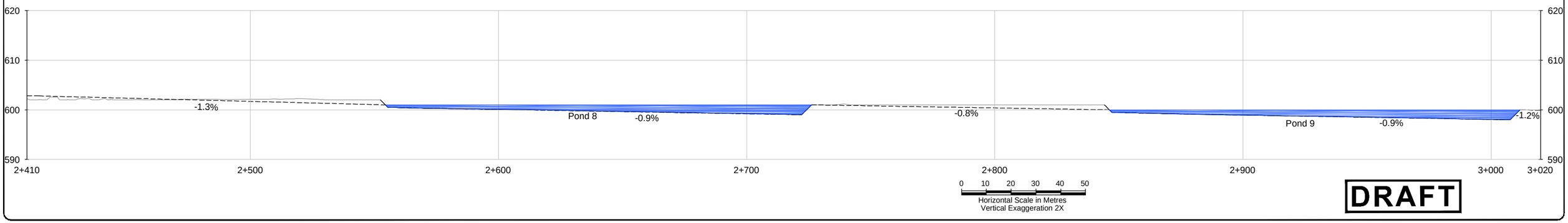

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SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

CAD/GIS No: KSM-TRC-012-018

DATE: Sept. 28, 2012

TITLE:

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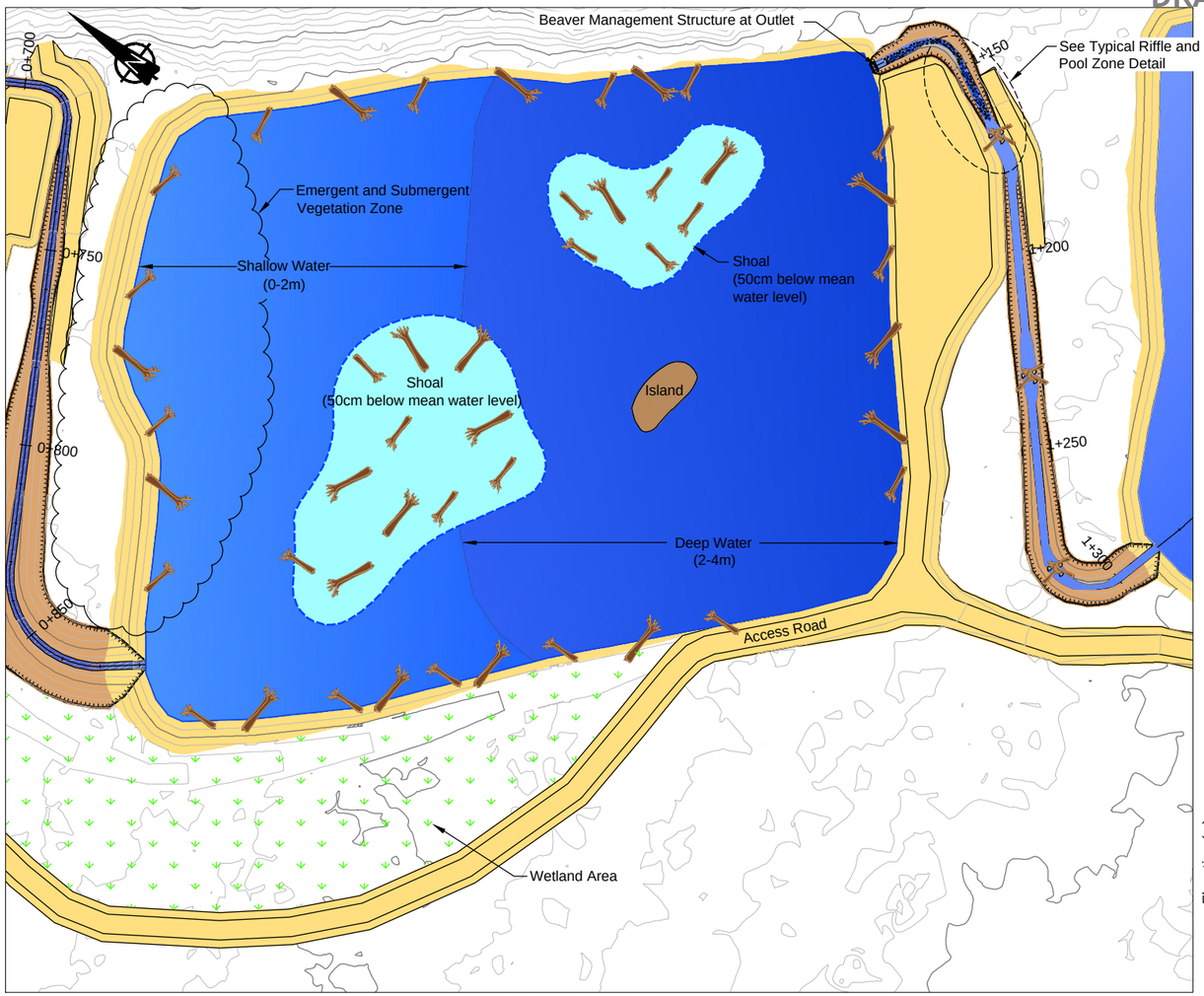

TYPICAL POND LAYOUT

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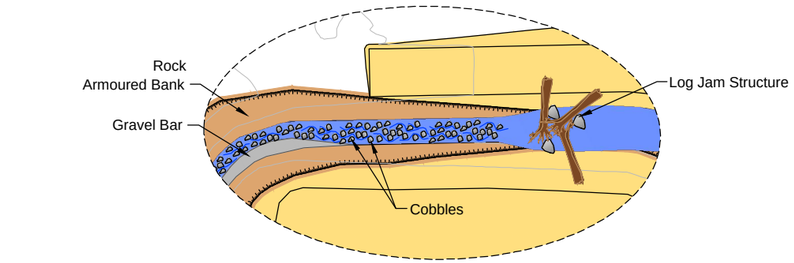

TYPICAL RIFFLE & POOL ZONE DETAIL

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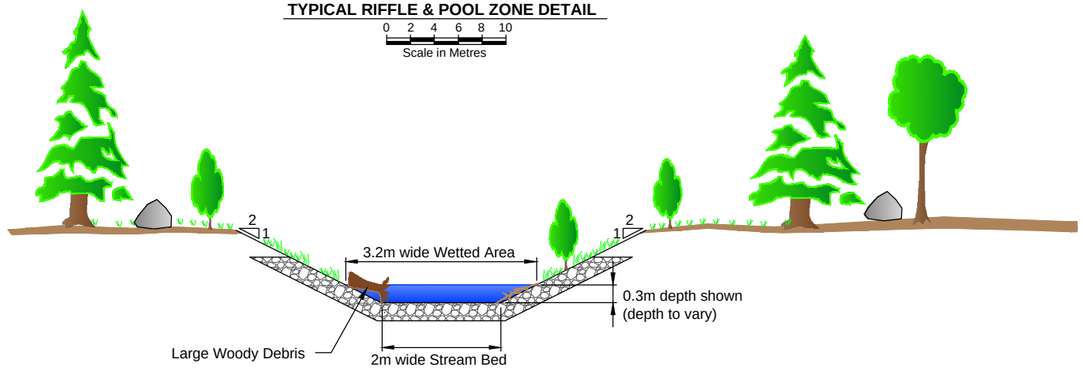

TYPICAL RUN ZONE CHANNEL SECTION

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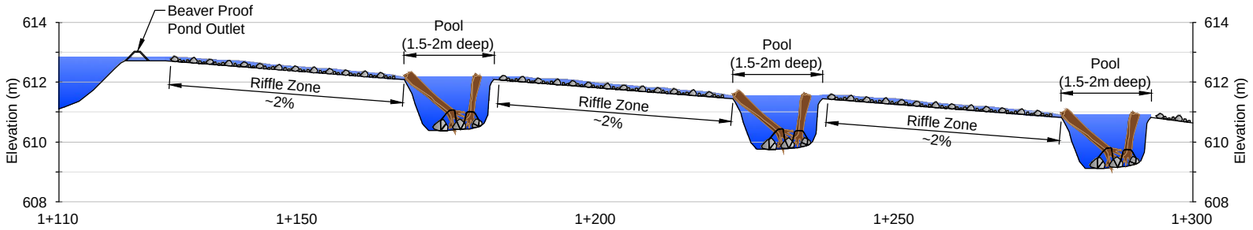

TYPICAL CHANNEL PROFILE

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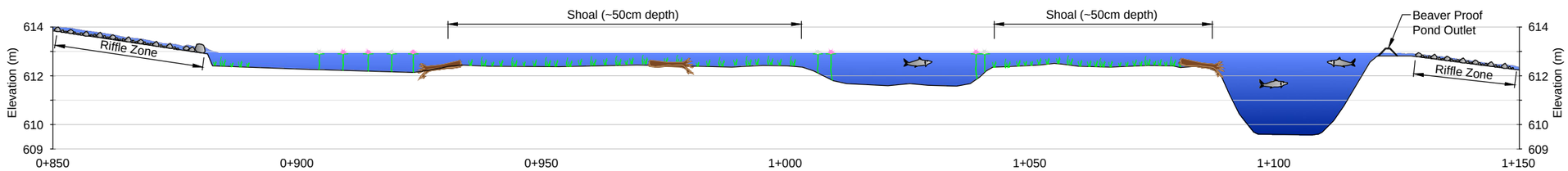
Vertical Exaggeration 5X



TYPICAL POND PROFILE

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Horizontal Scale in Metres
Vertical Exaggeration 5X

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PROJECT

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CAD/GIS No: KSM-TYP-012-026

DATE: Oct. 18, 12

TITLE:

Pond and Channel Typical Plan and Sections

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- Appendix C -

Photographs

Plate 1. High angle view looking down valley at Treaty Creek and the wide valley plain that exists down valley from lower North Treaty Creek (arrows denote flow direction).

Plate 2. High angle view looking up valley along Treaty Creek towards the natural water courses and wetland areas that exist across and the wide valley plain that is adjacent to the active stream channel (arrows denote flow direction).

Plate 3. Installation of drive-point piezometers at proposed pond location

Plate 4. Installed piezometer at proposed pond location in Treaty Creek

Plate 5. Checking water level and sampling of piezometer.

- Appendix D -

Risk Analysis

Risk Analysis: Treaty Creek

Criteria		Proven	Inferred	TBD	Suitable for Project	Possible Consequences	Likelihood of Consequence Occuring	Mitigation	Risk to Project	Consequence/Comments
Water Supply	Surface Waters	Hydrometric monitoring ongoing since 2008 in North Treaty and 2010 in Treaty			TBD	Insufficient surface water	moderate	Rely on groundwater for water supply	low	
	Ground Waters	Standpipes were installed June 2012			TBD	Groundwater insufficient	low	Rely on surface water intake	low	Groundwater based open water is observable throughout the year.
	Total Water	Yes, from standpipes and hydrometric station			Yes	Combined water sources insufficient for project	low	Use Treaty Creek or other creek (e.g. at south end of project) to augment groundwater and surface water sources	low	Existing data suggests that either surface water or groundwater alone may be sufficient so the combination of the two will provide sufficient water supply.
Channel Stability	Flood Risk	Assessed by geomorphologist			Yes	Flood Damage to Project	low	Construct project to withstand a 25 yr event	low	Overall, existing flood risk to compensation area exists as assessed by geomorphologist & professional engineer can be mitigated by engineered design and will be evaluated by modelling during design phase.
	Avulsion Event	Assessed by geomorphologist			Yes	Impact Damage to Project	moderate	Layout project outside of debris torrent or terrain hazard pathway	low	Project components near the apex of the alluvial fan will be located downstream of and protected by proposed bridge structure.
Earthworks	Suitable Building Materials		Terrain mapping and ground inspections		TBD	Unsuitable materials for earthworks construction	low	Find local borrow source or engineered alternative	low	Proximity to mine access road and other earthworks improves feasibility of endhaul and borrow operations.
	Excavation Volumes		LiDAR based terrain model		TBD	Excess spoil generated	low	Endhaul excess materials and store at a safe area	low	Depth to groundwater level will determine the final elevation of channels and ponds.
Project Layout	Location and Gradient	Yes, by LiDAR and Survey data			Yes	Habitat requirements necessitate a realignment to improve gradient	low	Realignment of channels & ponds to improve habitat suitability.	low	Current layouts are based on LiDAR data and some local total station surveys.
	Intake Structures	Stable location associated with proposed bridge			Yes	Detailed analysis finds that intake location is not suitable	low	Find a suitable intake location. Rely on groundwater	low	If surface water intake not possible, then will need to rely on groundwater as primary water source for compensation area and size ponds and channels accordingly.
	Outlets/Fish Access	Yes, multiple options exist			Yes	Access is effected	moderate	Provide adequate protection at outlet area to maintain access. Provide secondary access where possible.	low	Evaluate secondary fish access points.
	Embankments	Embankments & protection dyke will be provided for construction access and flood protection needs	Assessed by professional engineer		Yes	Embankment failure	low	Conduct flood and scour analyses and size embankments accordingly	low	Materials observed during field visits and by hand-dug test pits ~1 m indicate suitable materials exist for embankment construction.
Maintenance	Beaver	Beaver already present in existing ponds			Yes	Beaver activities affect pond function	moderate	Active wildlife management will be required	low	Management strategies will be developed in conjunction with a wildlife biologist.
	Sediment		low		Yes	Sediment is deposited in ponds	moderate	Maintenance required to remove sediment and maintain pond depths	low	Intake structures will be designed and located to exclude sediment. Reliance on groundwater will minimize sedimentation.
	Repair		low		Yes	Damage to pond, channel or embankment structures	moderate	Maintenance required to repair damage to system	low	System components will be designed to withstand a 25 yr event.

Notes:
***Proven** - Detailed data has been collected that can quantify or otherwise confirm the resource.*
***Inferred** - No extensive data set exists to prove the resource but ground investigations, review of other related data, and professional judgement have been used to infer the resource.*
***TBD** - Not enough information exists to make a determination at this point.*
***Sufficient for Project** - The proven or inferred resource will be sufficient for the design of the project or does not pose a threat to the design (e.g. no threat from flood would be a "Yes" in sufficient for project column).*
***Possible Consequences** - What are the consequences associated with a resource being insufficient (e.g. not enough surface water - consequence reliance on groundwater).*
***Likelihood** - What is the likelihood of occurrence associated with the possible issue/deficiency with the resource based on the information available.*
***Mitigation** - Method of mitigating risk (e.g. flood risk - build larger dyke).*
***Risk to Project** - Given the consequence and the likelihood, what is the risk to the project (e.g. high consequence * low likelihood = moderate risk).*

Appendix 6.3-3

Technically Feasible Design Memo – Taft Creek Site 1 (MMER)

Rescan™
Engineers and Scientists

Draft Memorandum

DATE: December 2012 Refer to File No.: B.1_Taft Creek Report.docx

SUBJECT: Taft Creek: Feasibility Assessment of the Proposed Fish Habitat Compensation Area

1. Introduction

This report provides the results from the feasibility assessment for the proposed Fish Habitat Compensation Area within the Taft Creek drainage basin. The work has been focussed on the engineering planning and development of a new off-channel habitat system that will be established southeast of Taft Creek.

The proposed Taft Creek Fish Habitat Compensation Area (the Project) is located approximately 40 km south of Bell 2 along Highway 37. Taft Creek flows southwest passing under an existing highway bridge and discharging into the Bell-Irving River. The proposed Project is located on provincial Crown Land.

This report includes a description of the methodologies that were used in the feasibility assessment work. A results and observations section follows that describes the findings from the investigative work as well as identified risks to the development of the Project. Based on the technical feasibility assessment completed, conclusions and recommendations are provided for the development of the Taft Creek Fish Compensation Area.

All figures and drawings are provided in appendices of this report.

2. Methodology

Field investigations were conducted during field trips in 2011 and 2012. Extensive ground and helicopter-based aerial observations were conducted during all field visits. The work in 2011 was focused on site assessments for locating the Project, as well as obtaining local topographic survey-based information at key locations along the route. Investigations in 2011 and 2012 were associated with developing an understanding of the hydrologic characteristics of the drainage basin, the geomorphology of lower Taft Creek, subsurface materials in Project area, groundwater presence within the proposed area, as well as designing the layout of the proposed fish habitat compensation system.

A range of survey techniques were employed to collect local topographic data at locations across the proposed habitat compensation area. Differential GPS (DGPS) equipment was used to collect mapping grade topographic data and to collect feature data at proposed intake and outlet locations. Compass and chain surveys were also used to collect additional topographic data across noted terrain features, and to further refine the DGPS data where necessary. Total station surveys were conducted at potential highway crossings and intake locations. In addition, field observations and aerial reconnaissance were conducted during all field visits.

Light Detection and Ranging (LiDAR) data was provided for the proposed fish habitat compensation area. The LiDAR data was utilized to develop a digital terrain model (DTM) for the area. The model also provided the basis for the engineering layout and development of the channel and pond system.

In 2011 and 2012, geomorphological assessments of the Project Area were carried out by completing a series of site investigations of local geologic terrain and channel conditions. This process also included an examination of historic aerial photographs and satellite imagery for Taft Creek.

Surface water monitoring along Taft Creek was initiated in May of 2012. A hydrometric station was installed immediately upstream of the Taft Creek Bridge along Highway 37. Since May 2012, flow discharge measurements and hydrometric levelling surveys have been completed on a monthly basis. Both the hydrometric station installation and the ongoing flow monitoring work have been completed in accordance with the *Manual of Hydrometric Standards in British Columbia* (RISC 2009).

Groundwater monitoring began in September 2012 within the Project Area. Groundwater discharge zones were identified during ground inspections in 2011 and 2012. In September, six test pits were excavated along the proposed Project layout. Using a track-mounted excavator, pits were dug to depths of up to 5 m below surface. At each pit, soil and subsurface materials at depth were recorded, with representative samples obtained for laboratory testing. Where groundwater was encountered, slotted PVC standpipes (2" ID) were installed for monitoring purposes. Standpipes were installed in 4 of the 6 test pits. Pressure transducers were installed in 2 of the 4 standpipes in order to continuously record local groundwater levels throughout the year. A representative ground water sample was taken from one of the installed standpipes.

3. Results and Observations

The results of the field investigations, office-based data review, and feasibility assessment are provided below. These results were used to develop the proposed systems presented as preliminary designs (see Appendix B).

3.1 Basin Description

The Taft Creek drainage basin extends south and west out of the Skeena Mountain Range and covers approximately 467 km^2. The creek is approximately 41 km long and the Project is located along lower Taft Creek near its confluence with the Bell-Irving River. The site is protected on its upstream extent by the Taft Creek Bridge and associated dyke, all of which appear to be located on or near exposed bedrock. The presence of the bridge has resulted in the abandonment of portion of the active floodplain. The project is mainly located on the former floodplain surface, and partly on a terrace. Ecosystems within the Project site are dominated by a canopy of black cottonwood, hybrid white spruce and subalpine fir. The understory is composed devils club, huckleberry, alder, dogwood and willow. Historical logging activities are found within the watershed area, including immediately adjacent to the Project to the east. Soils are primarily alluvial in origin consisting of a well-graded mix of boulders, cobbles, gravels and sands.

3.2 Channel Geomorphology

Taft Creek is a high energy cascade-pool channel controlled along its lower 2 km by bedrock outcroppings and the highway bridge. There is little large woody debris (LWD) found within the channel itself and LWD that is present tends to be associated with the bridge abutments or in channel margin accumulations (i.e., jams). The substrate consists of coarse sands and gravels to cobbles and large boulders.

The dominant controlling feature of the reach of Taft Creek adjacent to the Project site is the highway bridge. It is clear from field investigations that Taft Creek once had an active alluvial fan associated with its confluence with the Bell-Irving River. However, since construction of the bridge a large part of the fan is no longer active and the channel has become entrenched within its current location for 30 years (Appendix A, Figure 4).

3.3 Hydrology

The surface water hydrology of Taft Creek was estimated from the hydrometric monitoring network that has been established within the KSM Project area (Rescan 2012). Using the Taft Creek drainage area, a synthetic daily discharge hydrograph was constructed based on Treaty Creek. The Taft Creek drainage area upstream of the Highway 37 bridge crossing is 467 km^2 producing an estimated mean annual discharge (MAD) of 22.10 m^3/s based on regional data. The installed hydrometric station will be used to validate the synthetic hydrograph.

Generally, peak annual flows occur in June and are related to snowmelt. During the fall, increased flows occur in response to intense rainfall events. Winter low flows tend to develop by mid-November and continue until spring freshet (Appendix A, Figure 5). Given a potential withdrawal rate of 10% of daily discharge and a 7-day winter low flow of 2.16 m^3s, there would be sufficient flow during low flow seasons to support a habitat compensation project. Habitat areas in ponds and channels will be scaled such that no greater than 10% MAD would be diverted to support them. To improve future MAD estimates, a hydrometric monitoring station was installed May of 2012 along lower Taft Creek.

3.4 Engineering Planning

The preliminary design of the proposed Project consists of a series of 10 ponds and interconnecting channel providing 46,609 m^2 of wetted area, fed primarily by groundwater. The purpose of the channels and ponds is to provide off-channel rearing, refuge and overwintering habitat. The Project is located southeast of Taft Creek and will follow existing depressions and abandoned channels that are present along the lower extent of the alluvial fan. The ten proposed ponds are connected by eleven channelized sections that are positioned downslope of the highway and extend south and parallel Taft Creek, discharging into the Bell-Irving River (Appendix B, Drawing KSM-TAC-012-009).

The ponds and channels presented in the preliminary design drawings (Appendix B) represent generic shapes that will be further developed during the detailed design phase. During this next phase, additional complexity and specific habitat features will be prescribed such as pool-riffle morphology, LWD placement frequency and orientation, shoal-island-deepwater complexing in ponds, and riparian prescriptions including low-bank wetland vegetation (Appendix B, Drawing KSM-TYP-012-026).

The following is a summary of the results from the completed engineering planning and assessment work that were used in the preliminary design phase:

- The design of the Project is based on the concept that open channels and ponds will be excavated below the existing ground surface to intercept subsurface groundwater flows and seasonal surface water runoff from the adjacent ground surface.
- Design criteria for the layout and dimensions of the ponds and open channels were derived from the spatial limitations of the site, channel and pond stability, habitat features, and habitat area required for compensation.
- The layout of the channels and ponds were based on the existing ground contours and were designed to integrate the ponds into the surrounding landscape to minimize earthworks construction volumes.

- The trapezoidal shape and size of the open channels will be sized to convey surface and groundwater that will be intercepted by the ponds and channel sections. The channel base width is 2 m with 2H:1V sideslopes excavated to depths up to 3 m.
- An average design flow of 0.1 m^3/s was used for planning purposes with the minimum water depth along the channel sections to be 0.3 m. This will result in an average stream velocity of 0.12 m/s^2.
- Average depth below ground surface to the groundwater table as encountered during test pitting varied from 1 to 3 m. Excavation depths could be on average 2 m below the water table.
- The outlet for the Project will be into the Bell-Irving River. The outlet will also serve as the access point for fish to enter the Project.
- A proposed surface water intake location is situated immediately downstream of the Highway 37 bridge crossing. Surface water may be supplied to the Project if insufficient groundwater exists.
- Based on an estimated MAD value of 22.1 m^3/s for Taft Creek, a 10% MAD value of 2.2 m^3/s could be extracted from the main stem. This volume of flow would be sufficient to maintain water quality in the ponds during winter low flow conditions.
- The design criterion for the depths of the ponds was determined by the need to provide ice-free overwintering habitat. The maximum winter ice thickness, as determined by winter ice core sampling in ponds in the area was 1.0 m. The design proposes that 50% of the area of each pond will be >2 m deep as measured from the outlet channel invert.
- Deeper water sections 3 to 4 m deep will be present within each pond. The depths of these sections will be determined, in part, by the minimum elevation of the local water table at each location.
- An access road and protection dyke will be constructed along the western extent of the Project. This embankment structure will be sized to withstand a 25 year flood event and will provide access during the construction of the Project. The structure will be constructed from materials excavated during the construction of the ponds and channels.

3.5 Risk Assessment

As part of the feasibility assessment for the proposed Project, a risk assessment was undertaken to identify information gaps and to quantify potential risk. The assessment was based on the available information and included an assessment of the water supply potential, channel stability, earthworks, layout of the proposed system, and related maintenance requirements.

During the risk assessment all available information was reviewed, significant information gaps were identified, any hazards associated with the known information or with gaps were considered. Possible consequences associated with the information or information gaps were then identified and a risk rating relative to the feasibility of the project was assigned. Finally, potential mitigation for associated risks was identified.

The risk assessment results are provided in Appendix D. The following is a summary of the risk assessment:

3.5.1 Water Supply

- The supply of surface water from Taft Creek is considered to be sufficient. Ongoing hydrometric monitoring will continue in order to refine MAD estimate and seasonal variability in flows.
- Standpipes have been installed to monitor groundwater elevation. Based on the groundwater levels encountered at the time of installation sufficient groundwater appears to be present to support the Project.

- Length and depth of groundwater collection channel to be determined to provide flow rates for channel design.

3.5.2 Channel Stability

- Reliance on groundwater will eliminate stability and flood risk associated with an intake structure.
- The lower 1 km of Taft Creek is stable due to the highway and associated dyke and maintenance activities upstream of the Project.
- Flooding potential along some downstream sections of Project should be evaluated during the final design process for the location of the access road and protection dyke.

3.5.3 Earthworks

- The abundance of well-graded coarse-grained materials are suitable channel bed substrates and construction materials for the access road/protection dyke.
- There is a limited supply of fine-grained materials, however, given the intention to construct a groundwater based system, there is expected to be little need for the construction of impermeable layers.

3.5.4 Project Layout

- Channel sections were maintained at 1 to 3 % gradients to provide suitable habitat for target species.
- Ponds were laid out along contours and within other landscape features to minimize earthworks.
- If a water intake is required, protection against local sediment and erosion will be required.

3.5.5 Maintenance Requirements

- Maintenance needs were evaluated to be at moderate risk for beaver-related impacts, low risk for sediment accumulation, and low risk for physical repairs to pond and channel sections and debris obstructions.
- Active wildlife management will likely be required on an annual basis to mitigate the potential effects of beaver activities within the compensation area.
- Outlet locations will be properly positioned and maintained to ensure continuation of fish access.

4. Conclusions and Recommendations

The results from the feasibility assessment for the proposed Fish Habitat Compensation Area along lower Taft Creek have been presented. Site investigation and engineering planning has been completed to confirm that the development of the Project is technically feasible at the proposed location. The low gradient terrain indicates that conventional excavation and construction techniques for the channels and ponds will be appropriate.

Taft Creek can provide sufficient surface water volumes to the Project area if necessary. The presence of groundwater along the proposed alignment indicates a high potential for groundwater to be the primary water supply source for the compensation network. The existing terrain provides suitable low gradient ground surfaces for the construction of the channels and ponds.

The designs presented in Appendix B show potential habitat area that is feasible to construct. The actual areas that will be constructed will be less than these potential areas and will be determined based on the habitat area required for sufficient compensation. The larger potential number is presented as optional area available as a risk mitigation measure.

The Project was chosen based on many biological and geophysical criteria. However, operationally, the proximity to existing or planned road infrastructure and the area available in the Taft watershed made this site suitable. Preference was given to building fewer larger projects as opposed to many small projects in order to more efficiently use resources and to focus maintenance activities.

Wetland habitat compensation is an additional component of the larger KSM habitat compensation program. Wetland habitat will be developed within the Project and wetland scientists have participated in the design of the Project to ensure both habitat types are included in the design. The combination of both fish and wetland habitat development is a natural corollary and will ensure an inclusive ecosystem approach to the development of the Project. The typical pond detail in Appendix B shows some examples of ecosystem complexing that will be implemented.

The Projects represent relatively large-scale construction activities and may require multiple years to make fully operational. As such, a staged approach to the construction of these Projects is recommended. This approach would allow for seasonal settling and stabilization, integration of regulator and stakeholder participation, design changes as required by site conditions, and sufficient flexibility to incorporate the Projects into the surrounding landscape while minimizing impacts to the existing ecosystems.

The following are recommendations for consideration in the future development of the Project:

1. The established surface water and groundwater monitoring programs should be continued so that the water sources are properly characterized for use in detailed design.
2. Detailed engineering surveys should be completed along the proposed alignment.
3. Based on the completed surveys, detailed design work is required to determine the final configuration of the channels, ponds, and access road/protection dyke.
4. Hydraulic modeling analyses should be completed to assess the functioning of the systems and the effect of habitat complexing on flow velocity distributions and water quality conditions across representative channel sections and ponds. In addition, detailed hydraulic scour analyses and channel bank protection requirements should be conducted.
5. A flood frequency and hazard analysis should be completed to determine the design flood levels across the Project and where additional embankment protection should be provided.
6. The construction-related earthwork volumes will need to be determined in conjunction with related cost estimate for constructing the Project.
7. A Construction Management Plan should be completed that will include road access details, borrow and spoil areas, material handling, construction sequencing, and an Environmental Management Plan for the Project area.

References

Resources Information Standards Committee, Ministry of Environment (RISC). 2009. Manual of British Columbia Hydrometric Standards.

Rescan. 2012. *KSM Project: Surface Water Hydrology Cumulative Baseline Report: 2007 to 2011*. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, British Columbia.

- Appendix A -

Figures

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PROJECT # 868-020-04-02 GIS No. KSM-10-169b_T November 7, 2012

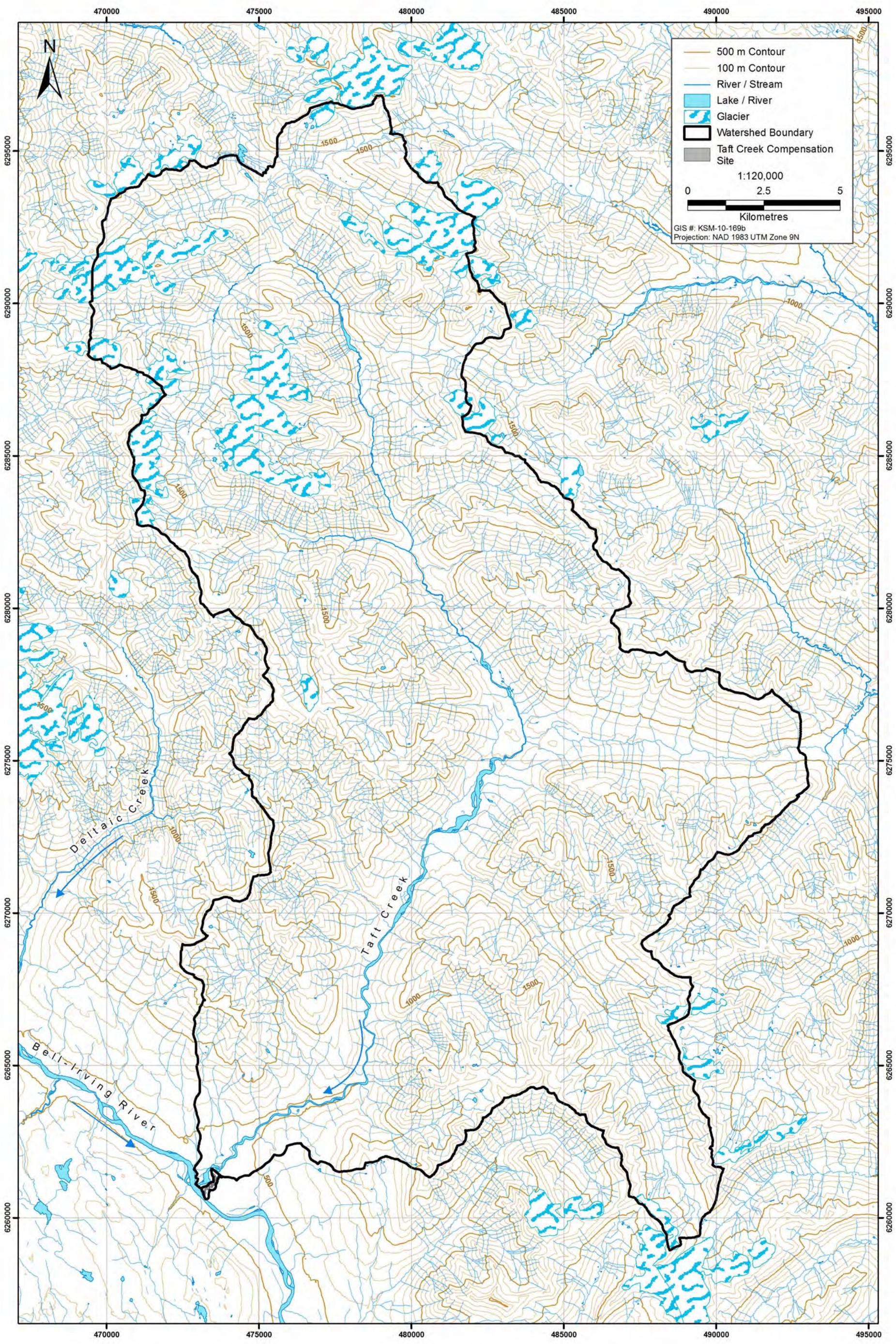

Figure 1

SEABRIDGE GOLD
KSM PROJECT

Drainage Area for Taft Creek Watershed

Rescan™ Engineers & Scientists

Figure 1

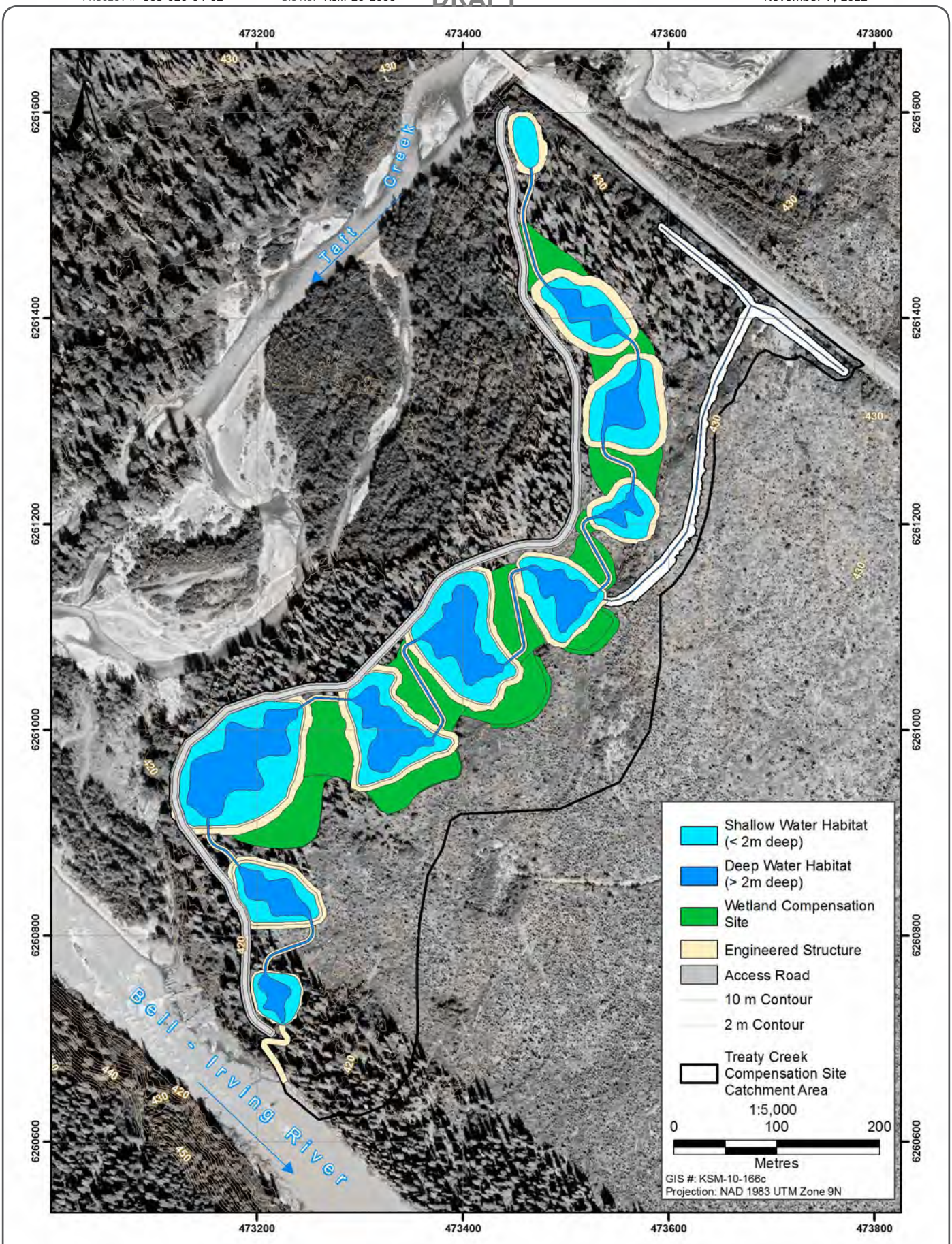

Figure 2

Drainage Area for the Proposed Taft Creek Fish Habitat Compensation Area

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Figure 3

Taft Creek Fish Habitat Compensation Area Overview

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Figure 4

Taft Creek Fish Habitat Compensation Area Overview

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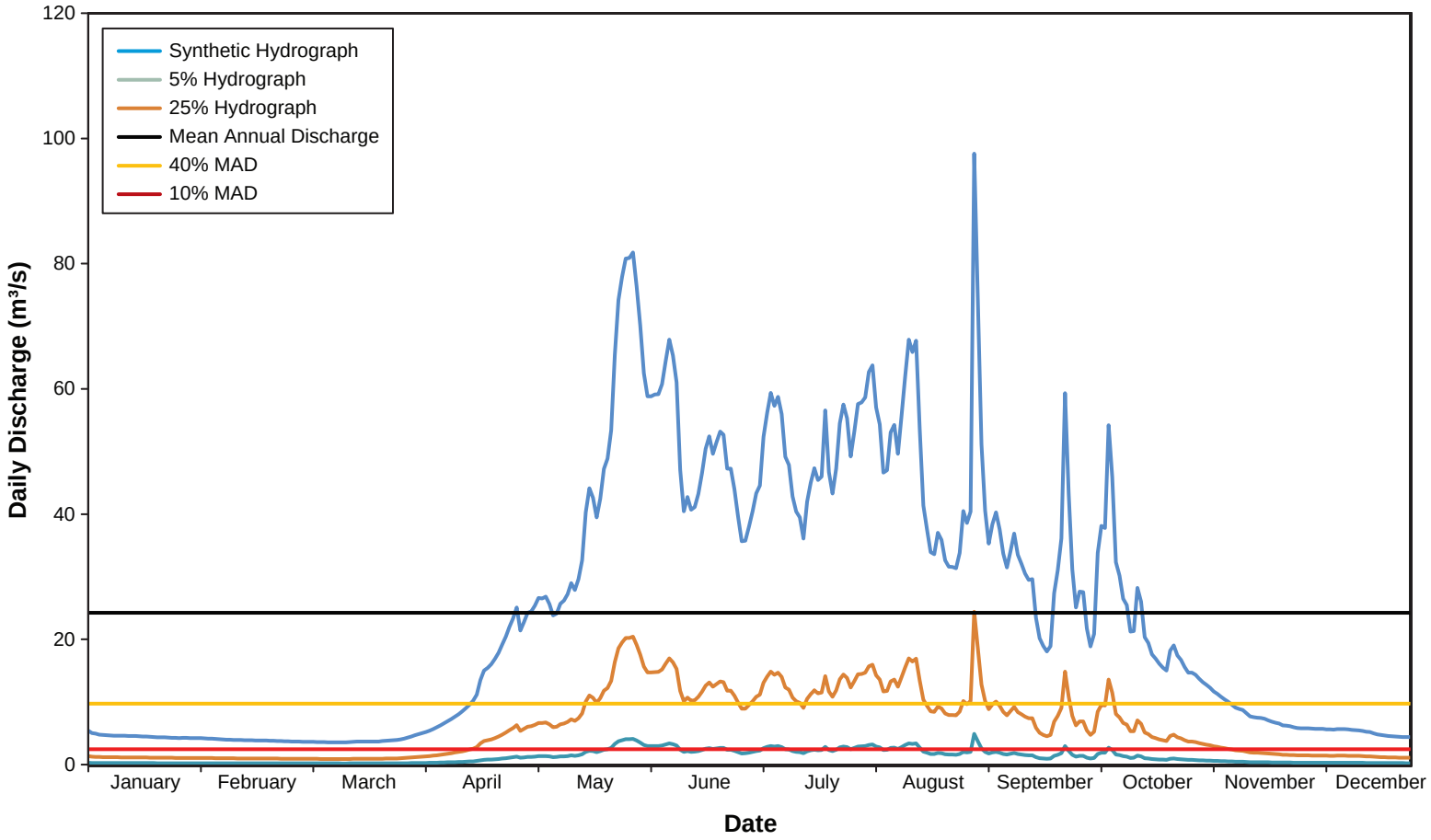

Figure 5

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Annual Synthetic Hydrograph
Taft Creek, Regional Analysis

Figure 5

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- Appendix B -

Drawings

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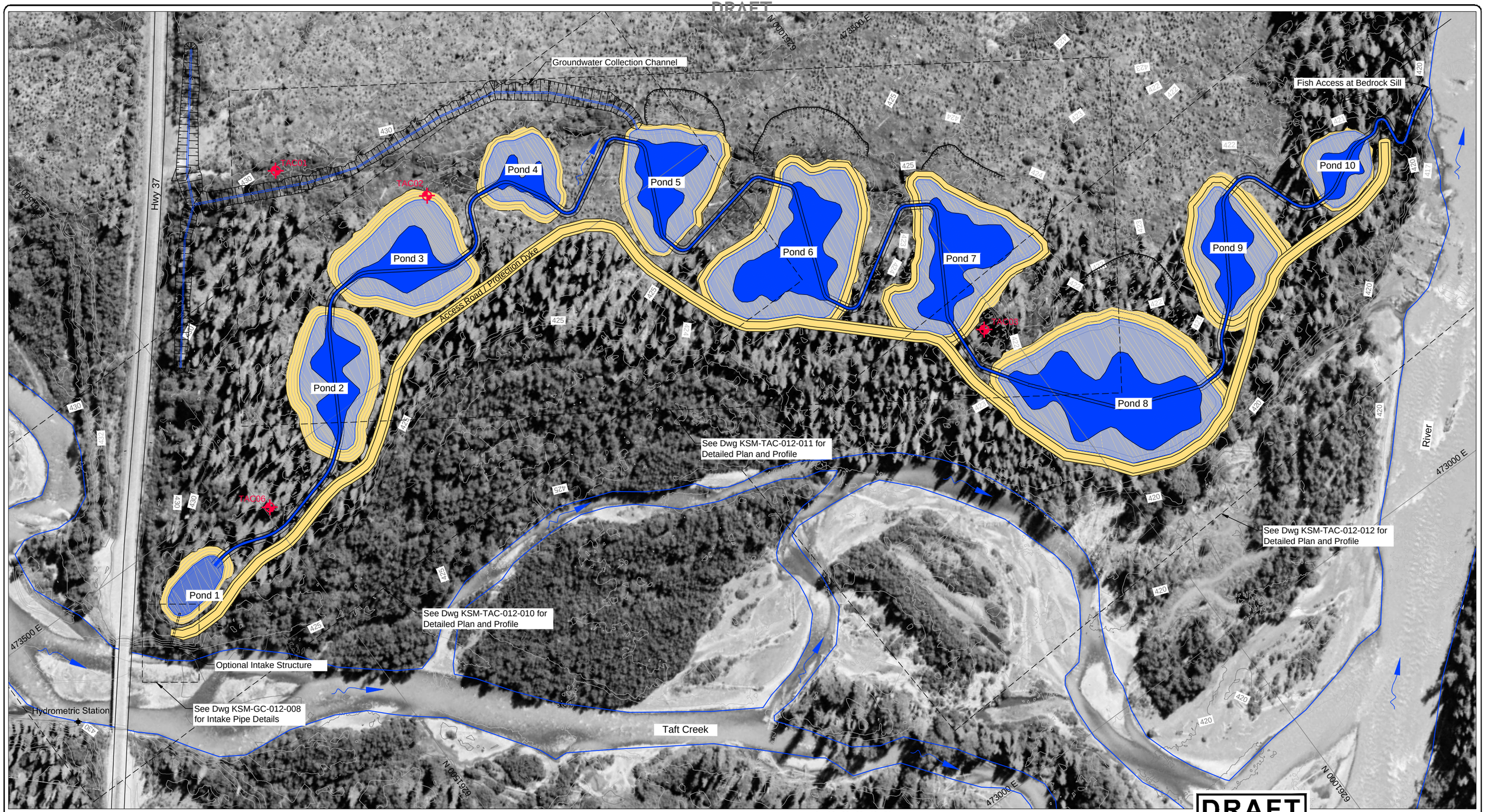

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NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

REVISIONS

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PROJECT

KSM Fish Habitat Compensation Project

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SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

CAD/GIS No: KSM-TAC-012-009a

DATE: Sept. 28, 2012

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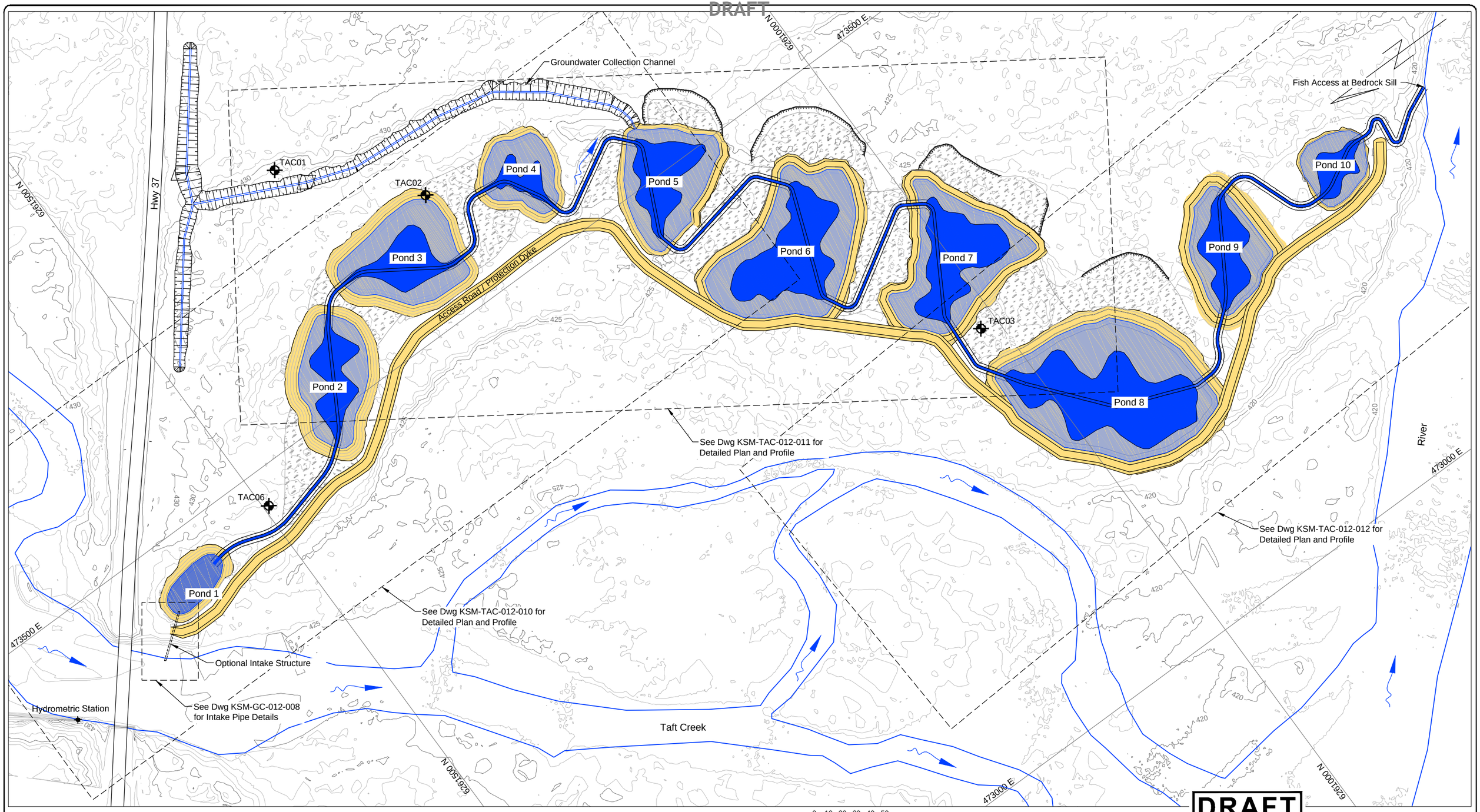

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A	Issued for Discussion	DG	BA	10Aug12

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DATE: Sept. 28, 2012

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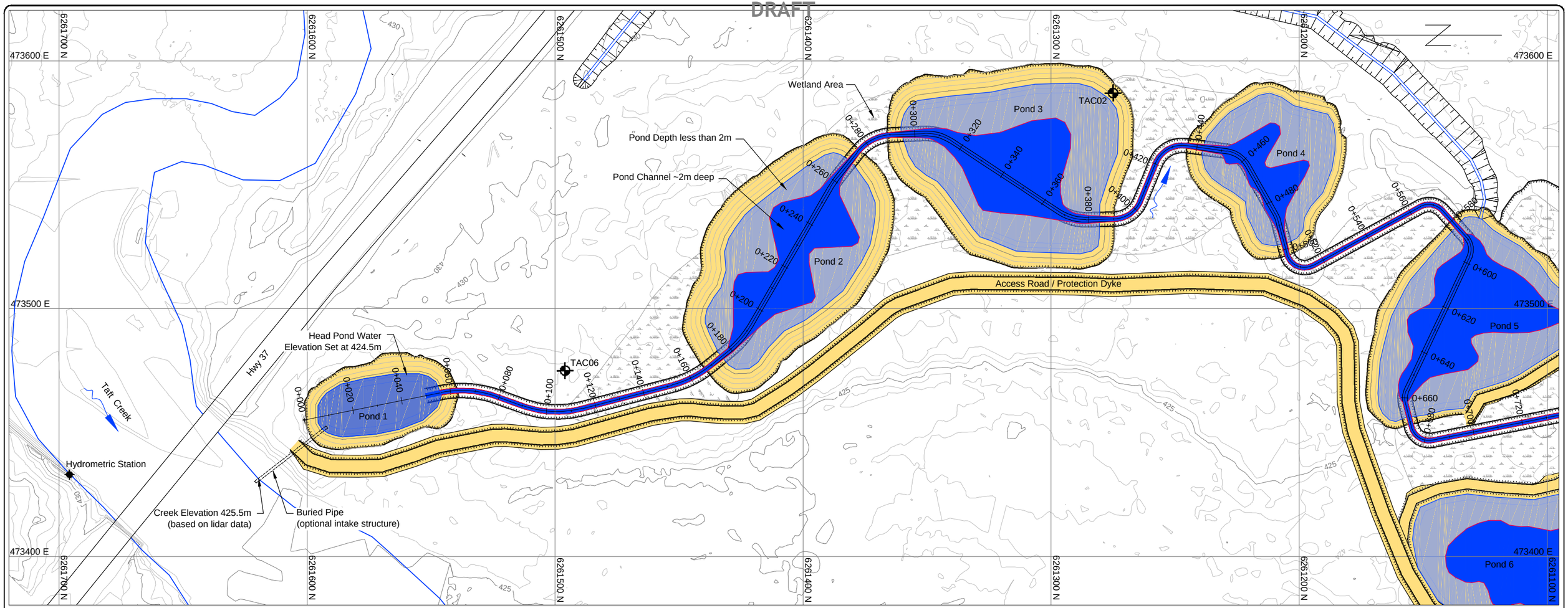

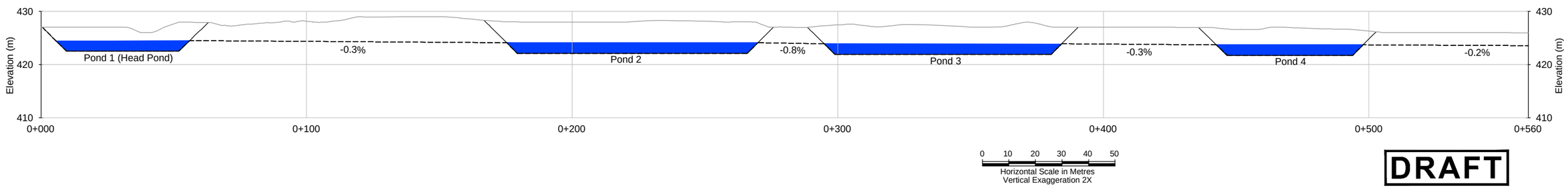

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A	Issued for Discussion	DG	BA	10Aug12

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Station 0+000 to 0+560

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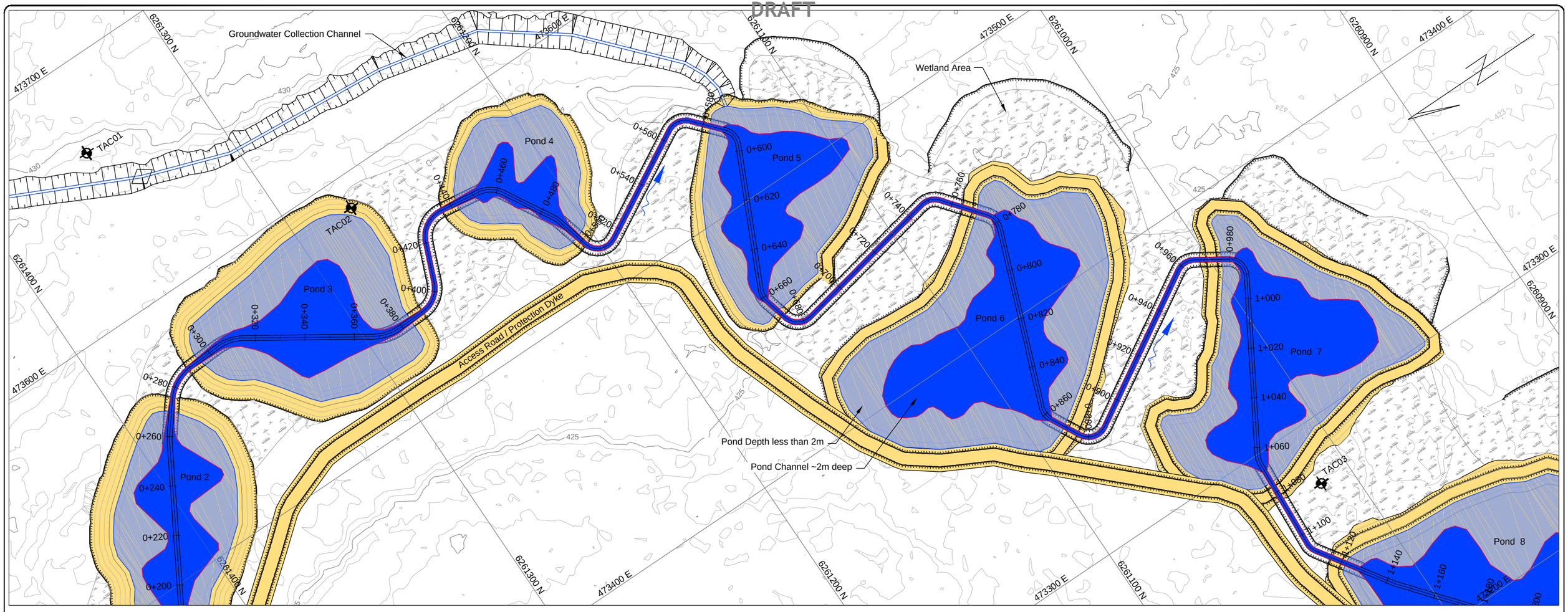

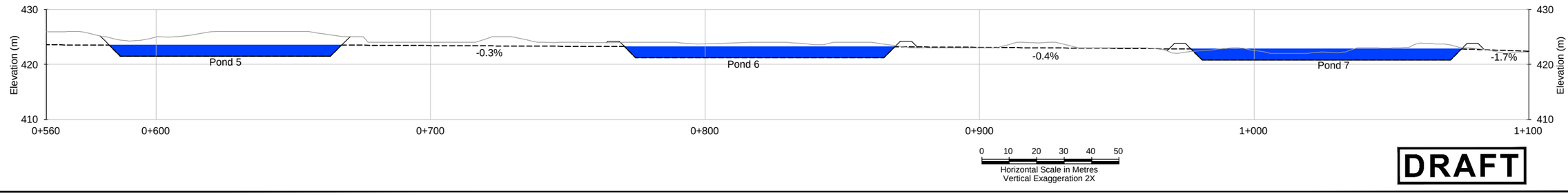

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A	Issued for Discussion	DG	BA	10Aug12

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Station 0+560 to 1+100

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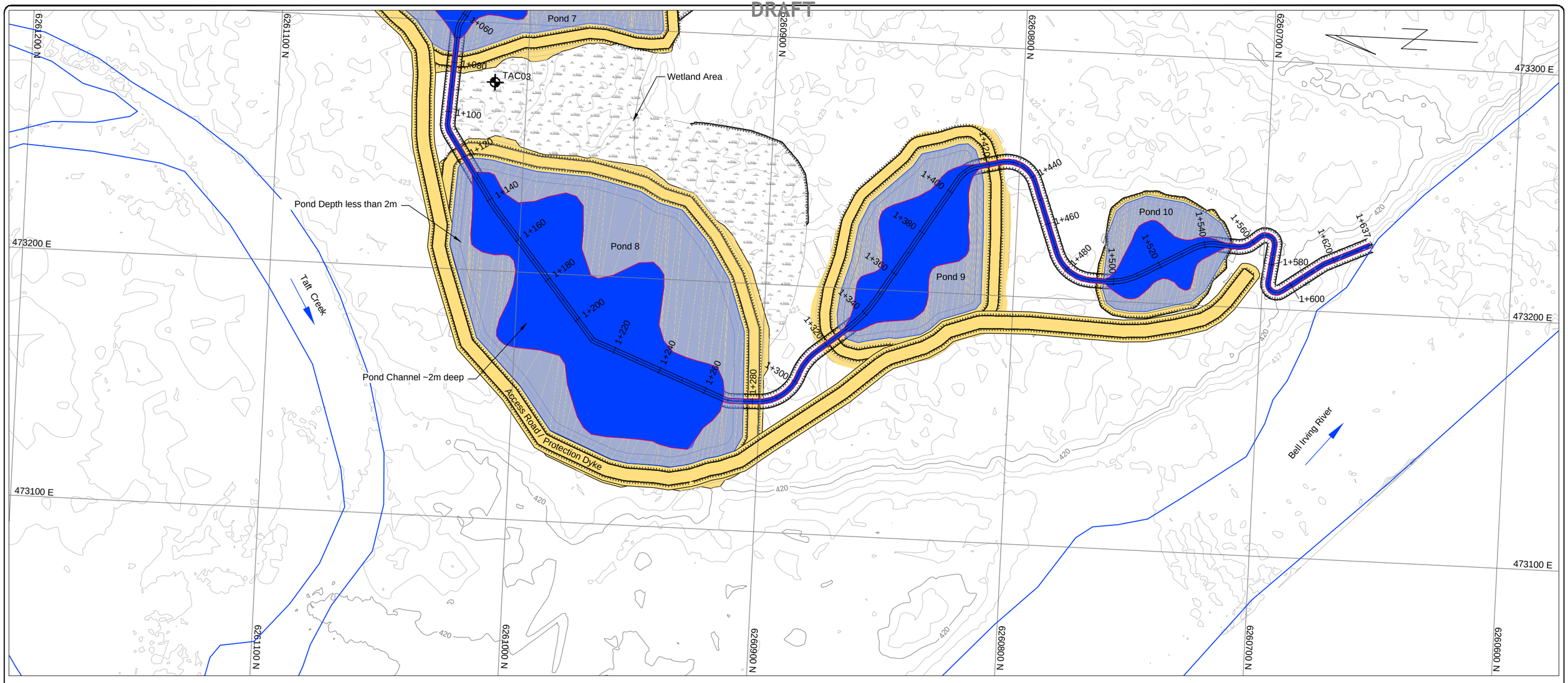

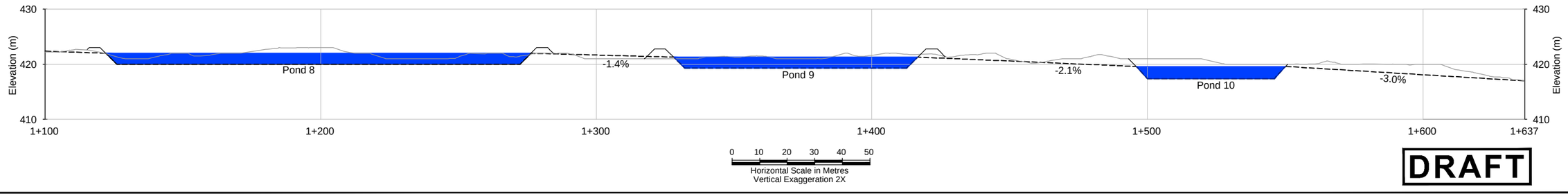

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CAD/GIS No: KSM-TAC-012-012

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TITLE:

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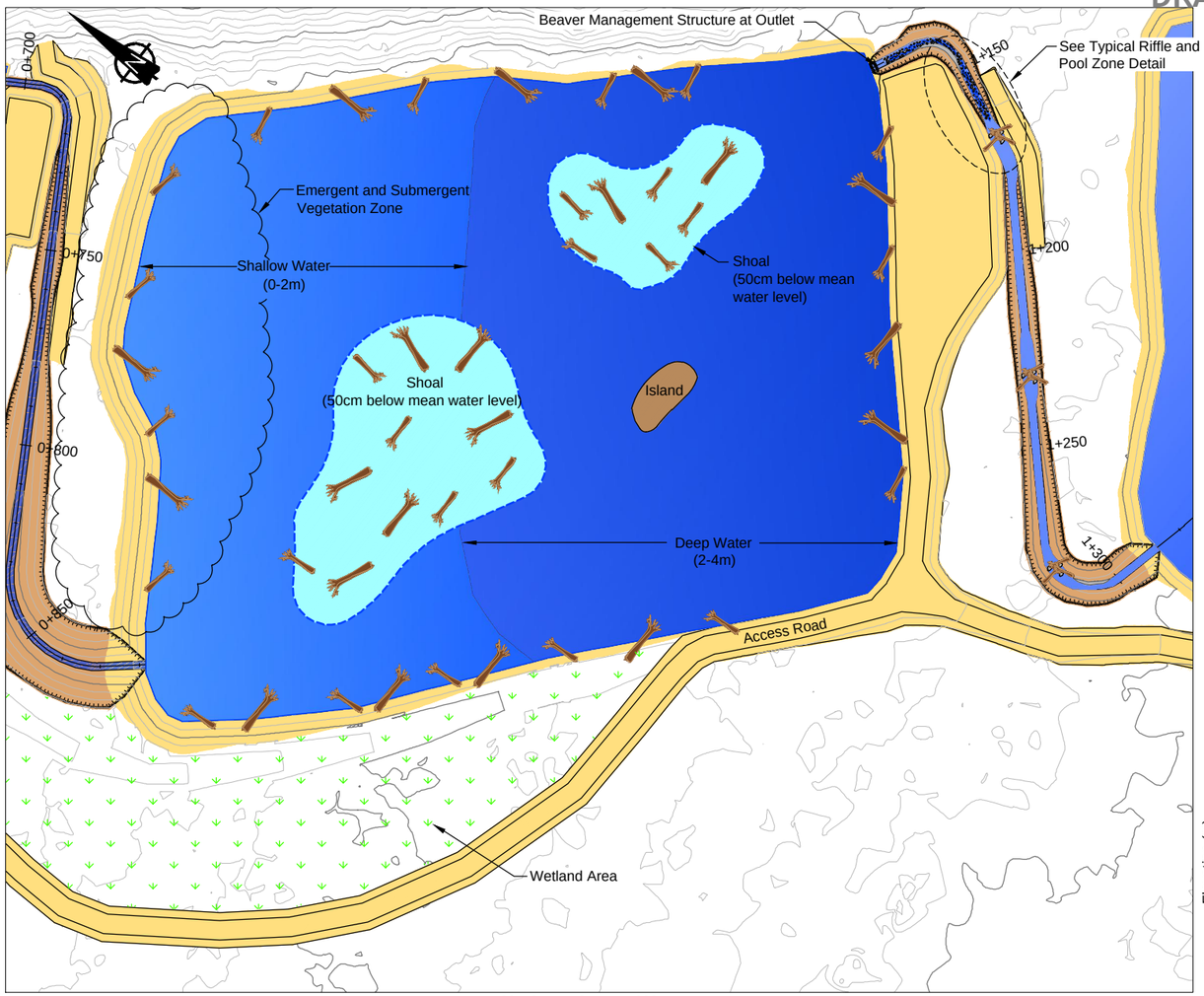

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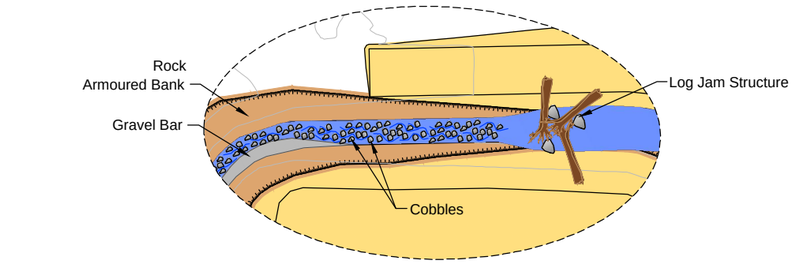

TYPICAL RIFFLE & POOL ZONE DETAIL

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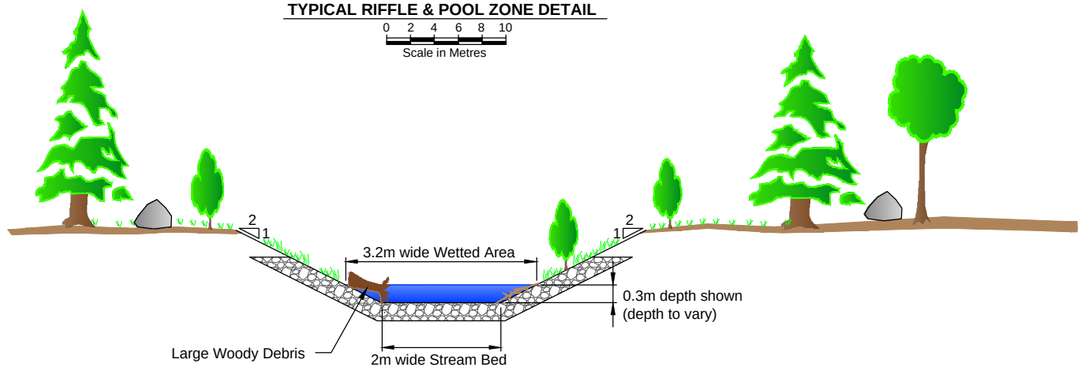

TYPICAL RUN ZONE CHANNEL SECTION

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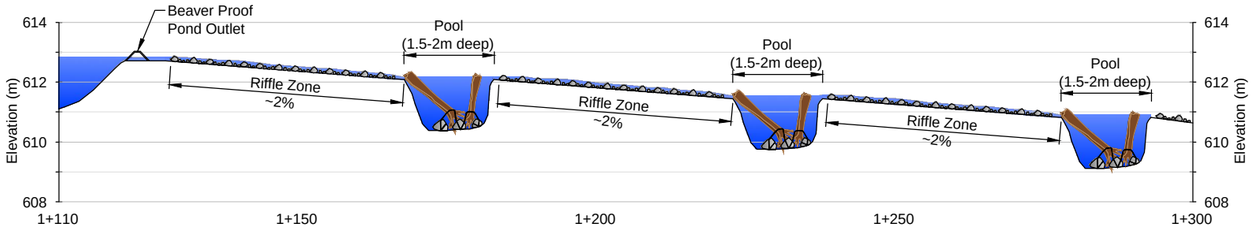

TYPICAL CHANNEL PROFILE

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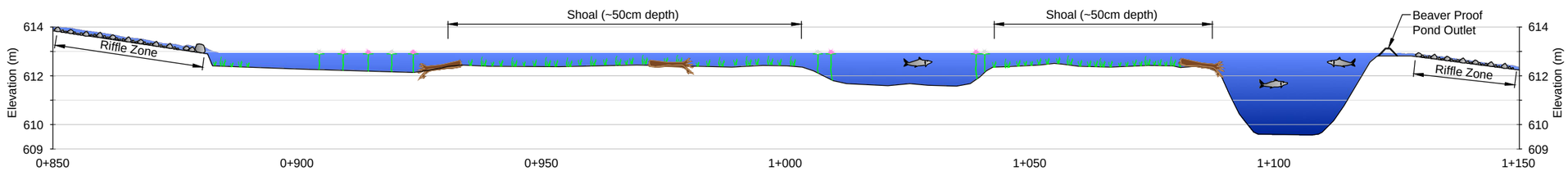

TYPICAL POND PROFILE

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PROJECT

KSM Fish Habitat Compensation

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SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

CAD/GIS No: KSM-TYP-012-026

DATE: Oct. 18, 12

TITLE:

Pond and Channel Typical Plan and Sections

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- Appendix C -

Photographs

Plate 1. High angle photograph looking south along Lower Taft Creek showing the existing terrain, the channel conditions and the location of the proposed Fish Habitat Compensation Area downstream and along the riparian area to the left of the main channel.

Plate 2:. High angle photograph looking north along Lower Taft Creek showing the Project location.

Plate 3. Aerial view of the Bell-Irving/Taft confluence and outlet location.

Plate 4. Example of materials found in test pitting at Taft Creek. Note groundwater seepage at the bottom of the hole.

Plate 5. Installing standpipe in test pit at Taft Creek.

Plate 6. Preparing standpipe for installation. Filter sock placed over the screened interval.

Plate 7. Backfilling and levelling ground after standpipe installation.

Plate 8. Well development, water level measurement and water sampling following standpipe installation at Taft Creek.

Plate 9. Reseeding after completion of test pit.

- Appendix D -

Risk Analysis

Risk Analysis: Taft Creek

Criteria		Proven	Inferred	TBD	Suitable for Project	Possible Consequences	Likelihood of Consequence Occuring	Mitigation	Risk to Project	Consequence/Comments
Water Supply	Surface Water	Hydrometric monitoring started in May 2012			Yes	Intake maintenance	moderate	Proposed Water Intake Location protected by Hwy 37 infrastructure	low	
	Ground Water	Standpipes installed in September 2012			TBD	If insufficient, water intake off Taft Ck will be required as primary water supply	TBD	Greater dependance on water intake to supply water to compensation area	low	Groundwater is present and water levels will be monitored to confirm seasonal variation.
	Total Water	Yes (see above notes)			Yes	Intake maintenance	TBD	Insufficient groundwater source implies greater dependance on surface waters supply water for compensation area	low	Taft Creek is a high energy system so preference is not to rely on surface waters as primary water supply to compensation area.
Channel Stability	Flood Risk	Assessed by geomorphologist			Yes	Flood damage to the Project	moderate	Proposed Water Intake Location protected by Hwy 37. Road access/protection dyke to be constructed to withstand a minimum 1:25 yr flood event	low	Overall, low flood risk as assessed by geomorphologist & professional engineer. Moderate risk levels exist along some downstream sections of drainage system and should be evaluated during the final design process.
	Avulsion Event	Assessed by geomorphologist			Yes	Impact damage to the Project	low		low	Bridge and bedrock at upstream end of project protects the area from avulsion.
Earthworks	Suitable Building Materials	Test pitting 2012			Yes	Detailed design yeilds complex materials requirements	low	Find local borrow source or engineered alternative	low	If insufficient amounts of suitable materials available present for earthworks construction, then will need to import materials to site.
	Excavation Volumes		Assessed by professional engineer	Detailed Design	TBD	Excess spoil generated from excavation	moderate	Endhaul excess materials and store at a suitable location	low	Depth to groundwater level will determine the elevation of channel bed and the amount of spoil materials that will be generated. IF insufficient amounts of cohesive materials are available then channel bed & sideslopes may need to be lined with impermeable materials.
Project Layout	Position & Gradients	Yes, by LiDAR and Survey data			Yes	Habitat requirements necessitate a realignment to improve gradient	low	Realignment of channels & ponds to improve habitat suitability	low	Current layouts are based on LiDAR data and some local total station surveys.
	Intake Structures	Suitable location protected by Hwy 37			yes	Detailed analysis finds that intake location is not suitable	moderate	Find a suitable intake location. Rely on groundwater	low	If surface water intake not possible, then will need to rely on groundwater as primary water source for compensation area.
	Outlets/Fish Access	Yes, multiple options exist			yes	Access is effected	moderate	Provide adequate protection at outlet area to maintain access. Provide secondary access where possible	low	
	Embankments	Yes, from test pitting 2012			yes	Embankment failure	low	Conduct flood and scour analyses and size embankments accordingly	low	
Maintenance	Beaver		low risk		yes	Beaver activities affect pond function	moderate	Maintenance required to manage beaver activities	low	No beavers or beaver habitat is present in Glacier Creek area.
	Sediment		low risk		yes	Sediment is deposited in ponds	moderate	Maintenance required to remove sediment and maintain pond depths	low	Groundwater based systems have significantly less sediment management requirements.
	Repair		moderate		yes	Damage to pond, channel or embankment structures	moderate	Maintenance required to repair damage to system	low	System components will be designed to withstand a 25 yr event.

Notes:
***Proven** - Detailed data has been collected that can quantify or otherwise confirm the resource.*
***Inferred** - No extensive data set exists to prove the resource but ground investigations, review of other related data, and professional judgement have been used to infer the resource.*
***TBD** - Not enough information exists to make a determination at this point.*
***Sufficient for Project** - The proven or inferred resource will be sufficient for the design of the project or does not pose a threat to the design (e.g. no threat from flood would be a "Yes" in sufficient for project column).*
***Possible Consequences** - What are the consequences associated with a resource being insufficient (e.g. not enough surface water - consequence reliance on groundwater).*
***Likelihood** - What is the likelihood of occurrence associated with the possible issue/deficiency with the resource based on the information available.*
***Mitigation** - Method of mitigating risk (e.g. flood risk - build larger dyke).*
***Risk to Project** - Given the consequence and the likelihood, what is the risk to the project (e.g. high consequence * low likelihood = moderate risk).*